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INDUSTRIAL RELATIONS AND "HUMANWARE"

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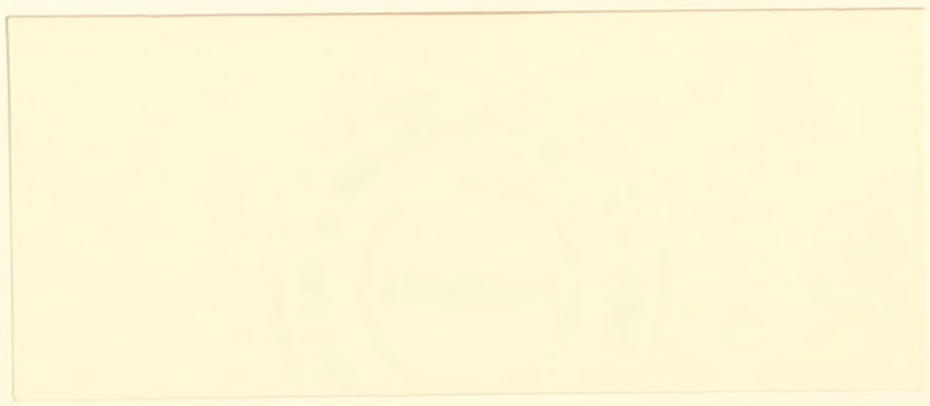

INDUSTRIAL RELATIONS AND "HUMANWARE"

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INDUSTRIAL RELATIONS AND "HUMANWARE":

Japanese Investments in Automobile Manufacturing in the United States

December 1986

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I. INTRODUCTION

In the last few years, Japanese investment in automobile manufacturing in the U.S. has increased dramatically. Following the pioneering investment of Honda in motorcycle production in 1979 and passenger cars in 1982, Nissan started building small trucks in 1982 and passenger cars in 1985. Toyota started a joint-venture operation with GM in California, where they started to produce cars in 1984. Toyota then launched a large scale independent investment in Kentucky in 1986. Mazda is building a large and highly sophisticated plant in the midst of the Detroit metropolitan area. Mitsubishi also has started construction of a large plant in Bloomington, Illinois this year working jointly with Chrysler. Fuji-Heavy Industry (Subaru) and Isuzu have just announced plans to build an assembly plant in Lafayette, Indiana.[1]

By the time all these investment projects are completed, around the end of 1988, the number of cars produced by Japanese auto makers in the U.S. will reach an estimated level of 1.5 million a year.[2] So far, their operations appear to have been quite successful. Production performance has attained consistently high levels, and industrial relations have been cooperative and peaceful. Will this successful performance continue? Will Japanese auto makers take over a major portion of automobile production in the United States? Or will they face obstacles or serious challenges in the long-run? If so, what will the problems be?

In the face of the large and growing presence of Japanese operations in the United States, has the interest of American automakers

in Japanese production methods intensified? What can American producers learn from the Japanese which could improve their own competitive position? Efforts are being made to learn from the Japanese experience both directly and indirectly through joint ventures, the exchange of information and other means. Will American corporations learn something from these efforts? And if they do, which lessons will be most useful for their purposes?

These are some of the intriguing questions which motivated this study. In what follows, we will first present in Section II a model of what we perceive to be the key elements of the Japanese production system. There, special attention will be paid to a critical dimension of technology -- the linkage between hardware and human resources, which we call "humanware." Section III will discuss the historical development of the Japanese production system and industrial relations as well as their linkage with the broader context of Japanese corporations and industrial society. Then in Section IV, the experiences of the Japanese plants in the U.S. will be reviewed, summarized in four major areas: recruitment and training, job structure and its administration, the reward system and its administration, and participation and industrial relations. In Section V, we will interpret our research findings and discuss the implications for the future prospects of these investments and the possibilities of mutual learning between the industries of the two countries. Finally, Section VI will present concluding remarks.

II. THE JAPANESE PRODUCTION SYSTEM: A HUMANWARE PERSPECTIVE

When you walk into Japanese plants operating in the United States, you may have several impressions. They look somewhat compact relative to American assembly plants producing a comparable quantity of cars. They generally have a stamping section combined with the assembly facility. However, other than that,they have essentially the same appearance as typical American auto plants. They employ the same basic production structure, the same kind of machines, and the same kind of work arrangements. American employees of Japanese plants work comparable hours at comparable wages with their counterparts in American plants.

However, the performance of Japanese plants has been so far much higher then many of their American counterparts. The quality of their cars has been graded among the highest of those being sold in this country.[3] Costs of production are considerably lower, and productivity is higher than comparable American plants.[4] They have so far enjoyed peaceful and productive labor-management relations.[5]

What accounts for this difference? What are the gimmicks? Their hardware technology for car manufacturing is basically similar to American auto plants. Indeed, the degree of sophistication in terms of, say, automation is even lower than some of the newly equipped American plants. Outside observers are therefore often tempted to conclude that the gimmick lies in "social organization." Japanese managers' emphasis on team spirit, mutual trust, and participation, in public remarks seems

to be supportive of this thesis. Not surprisingly, the social organizational side receives much attention in recent innovative efforts to improve the performance of American plants. Management and union officials in some plants are eager to foster a "team" approach to work organization and to develop participatory employee involvement programs.

In the authors' judgment, however, the matter of central importance lies neither in hardware or social organization alone. The essence exists in the combination or in the intersection of the two. Let us name this as "humanware." This is an important aspect of technology, which is often ignored and has not been given sufficient attention.

A. "Humanware" defined

The concept of technology, as it is generally used, connotes machines or hardware. However, the hardware cannot work by itself, without human actions. If we define technology as a way to produce outputs, that which is confined and embodied only within hardware is in effect only a subset of technology. Technology becomes a meaningful concept only after the role of human resources, interlocking and interacting with hardware, is included. As shown in Figure 1, we may define this interactive relationship between hardware and human resources as "humanware", a broader and more meaningful sense of technology. It is our view that the answer to the questions we ponder lies in the domain of "humanware," rather than in the narrower areas of hardware technology or social organization alone.[6]

FIGURE ONE

HUMANWARE

BROADER CONCEPTS OF TECHNOLOGY

INTERDEPENDENCE BETWEEN HARDWARE

AND HUMAN RESOURCES

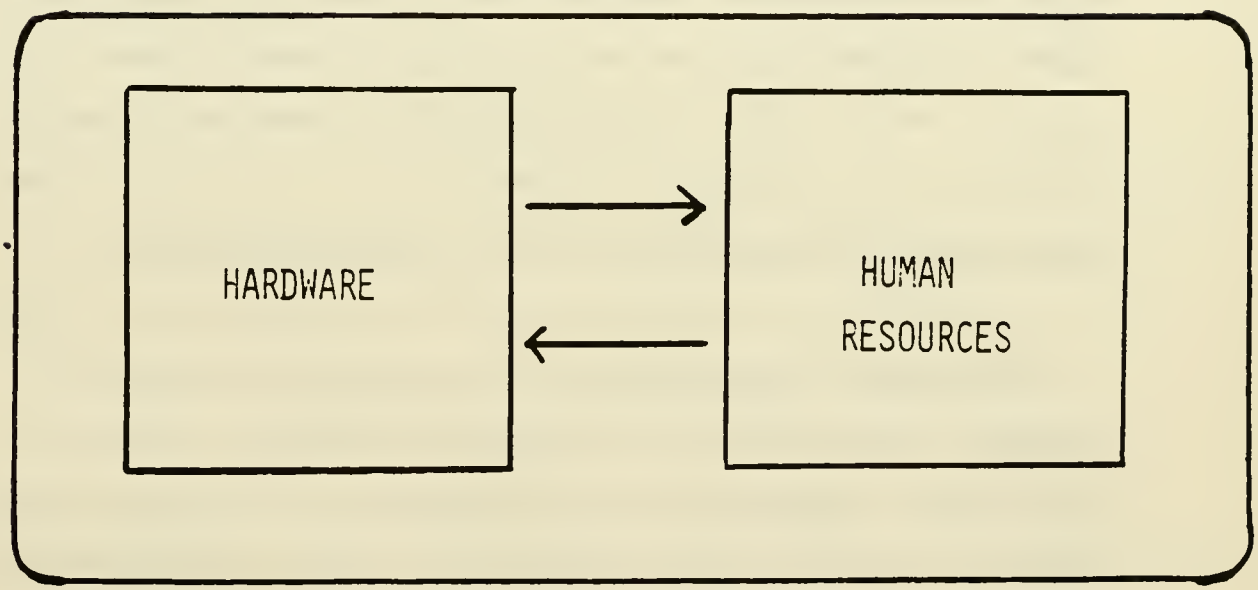


Figure 1 about here

This perspective is useful in understanding critical differences between production systems. Some degree of interaction of hardware and human resources is integral to all production systems. This interaction can be characterized by the degree of interdependence between human resources and hardware -- the degree to which particular capabilities of people are crucial to the effective performance of the hardware, and to which the utilization of the hardware as part of a production system affects the performance of people. The greater the interdependence, the greater the dependence of the overall production system on human resources, and the greater the vulnerability of the system to human variability. This dimension of vulnerability is, as we will see, a key factor in differentiating Japanese and U.S. production systems.

The effect of human resources on the performance of hardware technology, represented by the bottom arrow in Figure 1, is perhaps self-evident. Machine operators must have the necessary skills and knowledge to operate the equipment properly, safely, and efficiently. But included in the notion of "humanware" is an expanded view of the contribution of human resources, one which belies a static view of hardware technology -- that the design and configuration of the hardware technology itself improves as a result of incremental refinements conceived of by the people who operate it (as opposed to engineers).

The top arrow, which suggests that hardware technology affects the capabilities of human resources, is less immediately apparent. We are accustomed to thinking of particular hardware technologies requiring certain capabilities, but don't tend to consider how the use of hardware technology, in the context of a particular production system, can create and reinforce the qualities which make human resources effective. It is this latter, dynamic view we emphasize here as part of "humanware", one which sees the production process creating the opportunity for continuous, ongoing learning (as opposed to a one-time "learning curve" effect). This draws our attention to the aspects of a production system, including scheduling, job structure, inventory policy, quality control, and so forth, and the degree to which they contribute to the development of human resource capabilities.

It is important to point out that the "humanware" of a production system is not determined by the type of hardware technology in use. The same equipment can be operated in a production system which emphasizes the discretion and control of operators, and hence is more dependent on human resources, or in one which minimizes that dependence by limiting the role of people. There is an element of choice, within constraints which may be social and cultural as much as technical, about the form of "humanware" that will be deployed.

Let us now use this "humanware" perspective to analyze the Japanese production system in the automobile industry. In this analysis, we will describe this production system in general terms,

stressing its most typical features. There are variations in the production systems used by different Japanese automobile makers in their day-to-day operations, and these will be explored further in Section IV.

Our analysis will follow the simple diagrammatic exposition of logical relationships in the Japanese production system shown in Figure 2. In the diagram, we can read the logical sequence from left to right. Located at the extreme left are the goals of corporations, which are followed sequentially by the steps necessary to achieve those goals. The diagram identifies five stages in this logical sequence. They are: corporate goals, production system outcomes, key features of production system, key human resource contributions to the production system and major requirements for human resource effectiveness.

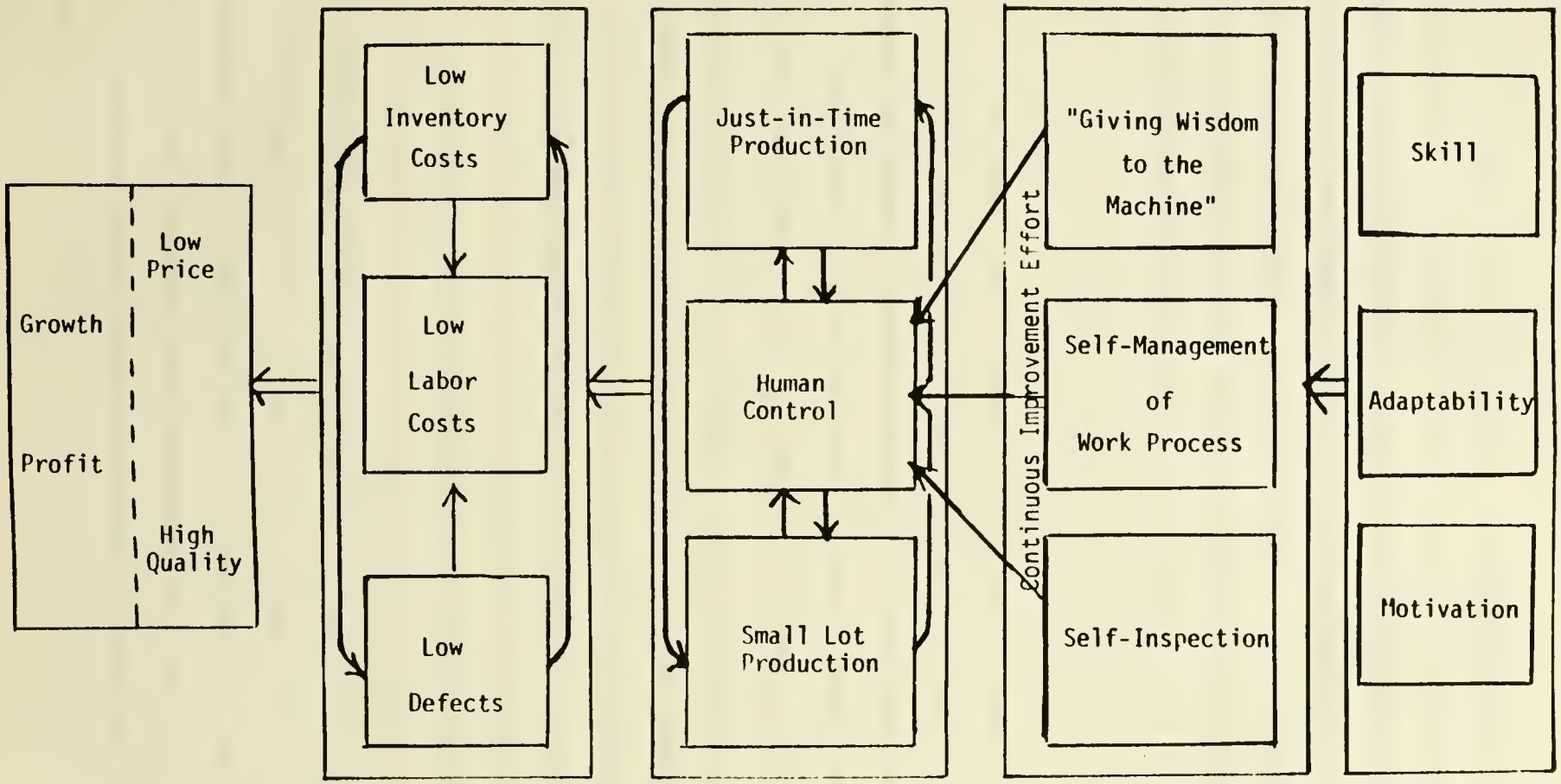
Figure 2 about here

B. Corporate Goals

Long-term corporate goals for Japanese automobile manufacturing corporations may reasonably be said to be corporate growth and profits.[7] In order to achieve these goals, it is imperative for them to win an ever-larger share of the competitive market. The two major requirements for increasing market share are to provide cars with high quality and at low prices. These define the targets for the next logical step.

FIGURE TWO

"HUMANWARE": THE JAPANESE MODEL



Corporate Goals	Production System Outcomes	Key Features of Production System	Human Resource Integration with Production System	Human Resource Effectiveness

C. Production System Outcomes

The production system must produce outcomes that directly realize these targets. The Japanese production system accomplishes this by yielding through its operation three critical outcomes: low inventory cost, low labor cost, and low defects. Note that low labor cost here is not in terms of a lower wage rate per worker but rather a lower labor input in terms of headcount to produce a given output.

It is important to realize that these outcomes are mutually reinforcing. For instance, lowering the inventory level to reduce inventory costs will necessarily reduce labor cost because the workforce needed to handle large inventory stocks can be eliminated.[8] Even more important is the relationship between reducing inventory and improving product quality. When the level of in-process inventory is kept high, production workers do not have to be overly concerned about defects or problems on the line because they can always rely on a buffer stock sufficiently large to assure an uninterrupted flow of production. In contrast, if the level of inventory is kept low, any problems on the line can seriously disrupt production levels, and consequently can impose painful losses on the company. To prevent such losses and disruptions, problems must be eliminated immediately from the production lines. Therefore, this system obliges people to identify the causes of the problems and cure them as quickly as possible. To the extent people are motivated to do so, the system may be said to have a built-in tendency to reduce defects and thereby increase product quality.[9]

At the same time, the requirement that incoming parts and materials have very few defects make it possible to run production without much buffer stock, further facilitating inventory reduction. Moreover, the low defects associated with intermediate products in the production process will eventually lead to low labor costs because there will be less need for final inspection and repair and thus the workforce for these tasks can be minimized.

D. Key Features of the Production System

The Japanese production system is designed to yield these outcomes through its operation. There are a number of technological features which characterize this system. Let us summarize here three critical features. They are: a) Just-In-Time (JIT) production, b) small lot production, and c) and human control, as shown in Figure 2. Since the JIT system and small lot production have some mechanical inter-dependence, we will discuss these two features in combination, and then discuss the role of human control.

1. Just-in-Time production system

The just-in-time system is a well known system of production in which inventory is minimized through just-in-time delivery of only the necessary inputs. Under this system, each production station accepts materials or inputs from either the preceding production station or an outside supplier of only the desired amount at the desired time. Consequently, both in-process buffer stocks and warehouse inventories

are minimized, and inventory costs are minimized. To carry out this task effectively, what may be called a "pull" system of information flow is widely utilized among Japanese companies.[10] The "pull" system, as opposed to a "push" system, sets the output level of a given work station only in response to the demand of the subsequent production station, rather than being given according to the centrally calculated production plan. While the "push" system, which has been the conventional mode of production among American auto producers, relies more on the centrally controlled computer system, the "pull" system relies heavily on alert and responsive contribution of workers at the production station, since maintaining the desired flow of goods depends largely on their judgment.

2. Small lot production

Small lot production is another feature which contributes to attaining the aforementioned desired outcomes of low cost and high quality. Small lot production, as opposed to large volume production, is advantageous because it can take advantage of quick and effective feedback between production stations in order to prevent defects or problems from proliferating.[11] Small lot production also helps the production process work with low buffer stocks and also smooths production flows, both of which contribute to minimizing costs. Lowering buffer stocks or smoothing the flow of production is possible only after a sufficiently high level of certainty or reliability of quality of inputs is attained, to which the method of small lot production contributes importantly.

It is worth noting once more that the successful execution of small lot production depends on the effective and continuous contribution of workers at the workshop. For one thing, the effective feedback of quality problems could not be achieved without the careful attention of workers,and for another, small lot production is only feasible with rapid machine set-ups, in which workers play a crucial role. These subsystems, namely the JIT system and small lot production, are thus mutually interdependent and also mutually reinforcing. They work jointly to yield low defects and low inventory, or in other terms, high quality and low cost. If this interdependence is broken at any point, the entire system will cease to operate effectively and will lose its efficiency. While these two technological features are critically interdependent, their role in the Japanese production system is supplemented and reinforced by the third integral element, human control.

3. Human control

Human control plays an integral role in the Japanese production system by providing it with a self-generating innovative capability. Here we will focus on three significant aspects of human control which promote this innovative capacity. One is what is commonly referred to at Japanese plants as "giving wisdom to the machine." Machines often have their own idiosyncrasies and are not always utilized to their maximum capacity. The more complex the machines are, the longer it takes to learn their idiosyncrasies and to utilize them fully. In other words,

the effectiveness of production equipment can vary significantly depending upon the way human resources work with them. Often, the effectiveness of machines at the workshop can be improved substantially by subtle modifications or refinements. This process of incremental improvements of hardware emerging from the experiences of production workers is often called "giving wisdom to the machines." Given the self-generating innovative nature of the system, a set of production equipment is no longer simply subject to automatic decay and depreciation but rather can be an asset whose capacity may improve and appreciate over time as a result of the interaction with human resources.

Another aspect is self-management of the work process. This means essentially that workers have a high degree of responsibility for controlling the work process. The most visible example of this practice is that workers specify the methods and procedures of the production process themselves. This practice is built upon the notion that workers at the workshop know the best what is actually going on at the production line, and often they have more information on actual production activities than engineers. The objective of giving a high degree of discretionary control to workers at the workshop is to take advantage of both their knowledge and sense of responsibility.

Somewhat related to this practice is the third aspect of human control, self-inspection. Workers at the production line are given both authority and responsibility of inspecting the quality of goods which they are producing. In the conventional American production system,

this function of inspection is normally left to specialized inspectors. The expectation in the Japanese production system is that by giving the inspector's function to all the production workers, defects will be minimized throughout the production process, preventing a gradual accumulation of problems towards the end of the line. While this system might have, all other things being equal, the effect of reducing the productivity of each worker, it certainly has a powerful motivational effect by involving workers in the effort to achieve greater quality. These motivational elements are instrumental in equipping the system with an autonomous innovative property.

This review of the key features of the Japanese production system reveals one essential characteristic. It is a system whose performance depends critically and sensitively upon the role of human resources. If human resources participate and contribute effectively in the production system, the system will operate efficiently and not only yield the desired results but also generate ongoing innovation. However, if human resources do contribute effectively, the system will not only become inefficient but will also cease to operate properly.

E. Key Contributions of Human Resources

Let us now shift our focus to the fourth stage of Figure 2, and the key contributions of human resources to the Japanese production system. This will require a closer look at three aspects of human control outlined above, with special attention to the continuous

improvement efforts which underlie all three, and which provides the system with its self-generating innovative capacity.[12]

1. "Giving wisdom to the machine"

First, let us elaborate on the concept of "giving wisdom to the machine". This refers to the innovative activities carried out through the joint efforts of production workers, engineers, and supervisors in an attempt to improve the capability of machines and production systems by modifying or adding relevant functions to them.

One such example is the development and attachment of autonomous defect control devices to machines and production systems.[13] This is highly effective in automatically preventing disturbances in production which might otherwise arise from careless human mistakes as well as defects or problems associated with machines or production systems. Production workers are often involved in the design and installation of these devices.

Another example may be found in the efforts to reduce the set-up times for machines. We pointed out above that a short set-up time is a crucial prerequisite for the system to take advantage of the merits of small lot production. In the case of stamping machines, the die change time has been shortened in Japanese auto plant from several hours a few decades ago to a few minutes in recent years.[14] Much of this improvement has been achieved through the joint efforts of production workers and engineers.

2. Self-management of the work process

A second component is self-management of the work process, which contributes substantially to the self-generating innovative property of the system. One example of this may be found in the practice of workers determining specific work procedures and methods. While production standards and the basic framework of work methods are given by engineering requirements, production workers have the discretion and the responsibility for specifying the work content. These specifications are extremely detailed, often including the recommended pattern of movement for a worker in performing a sequence of tasks or caveats about problems frequently encountered during particular operations. This level of detail resembles the ideal of scientific management propounded by Frederick Taylor and his disciples, but with one crucial difference: the workers, rather than managers or engineers, have control over the specification of work methods, and revise them continuously, based on their daily production experience.[15]

Related to this is the role of workers in making continuous adjustments in labor input. Workers help to adjust the division of labor for a a certain set of tasks, keeping labor input proportional to the volume of production at a given period of time. Workers also help reduce labor input by reorganizing work content and methods whenever it is desirable and feasible. This effort is extremely important in maintaining and improving labor productivity.[16] It can only be carried out after workers have acquired full knowledge and understanding of the

work process and job structure, and have mastered the skills needed to perform those jobs flawlessly. The continuous adjustment of labor input, therefore, involves a great deal of learning as well as strong motivation and flexible adaptability on the part of workers.[17]

It must be noted that self-management in this context means something quite different from the worker autonomy envisioned in blueprints for industrial democracy. Worker control is limited to the area of work methods, and even there is constrained by the parameters of the production process as a whole. Within these bounds, however, workers are free to make revisions in work methods and modifications in equipment design and configuration which make the job easier for them to carry out, as well as changes which are more clearly related to boosting productivity. Engineers have the role of supporting production workers in making these changes.

3. Self-inspection

The third component is self-inspection. Workers in Japanese plants have dual responsibilities: to operate machines and to inspect products at their own station. This has significant implications both for product quality and work organization. By inspecting the quality of intermediate products at each production station, defects or problems which would otherwise be passed on to subsequent stations can be corrected. This method not only helps to minimize product defects but also helps to minimize costs by reducing compounded defects which would otherwise accumulate towards the end of the production line, thereby

reducing the needs for inspectors at the end of the line. This work organization contrasts sharply with that of conventional American assembly plants where production workers specialize in operating machines and a large number of specialized inspectors are engaged detecting any defects in final products.

Workers are given some control over the production process in order to prevent or correct defects at their work stations. One oft-cited example is workers' discretion to stop the line when they feel it is necessary to correct a problem. Needless to say, the effectiveness of such a system depends on the alertness and responsibility of workers on the shop floor. The peer pressure that emerges from fellow work team members plays an important role in this system, since passing on a defective part directly affects their performance. Peer pressure also moderates against frequent line stoppage, since the whole team must then get involved in clearing the line of backlogs or defective parts and remedying the problem. Nevertheless, no feature more clearly reveals the potential vulnerability of the Japanese production system than that of stopping the line, since, in the absence of any buffer stock, a mistaken or malicious stoppage could bring the entire system to a halt.

F. Human Resource Effectiveness

The Japanese model of production, which integrates human resources fully into the production system as described above, depends critically and sensitively upon human resource effectiveness.

Now, let us consider what "human resource effectiveness" means. It is our view that there are three major dimensions of human resource effectiveness: skill, motivation, and adaptability. Each of these is indispensable to make human resources an effective productive asset, and all are closely interdependent. Their relationship is described in Figure 3.

Figure 3 about here

A worker can be skilled, but if he is not motivated he cannot be effective. And even if he is both skilled and motivated, if he can not adapt to necessary changes in the production environment, he will not be useful. The question we are interested in is how to foster and develop these critical traits in the workforce.

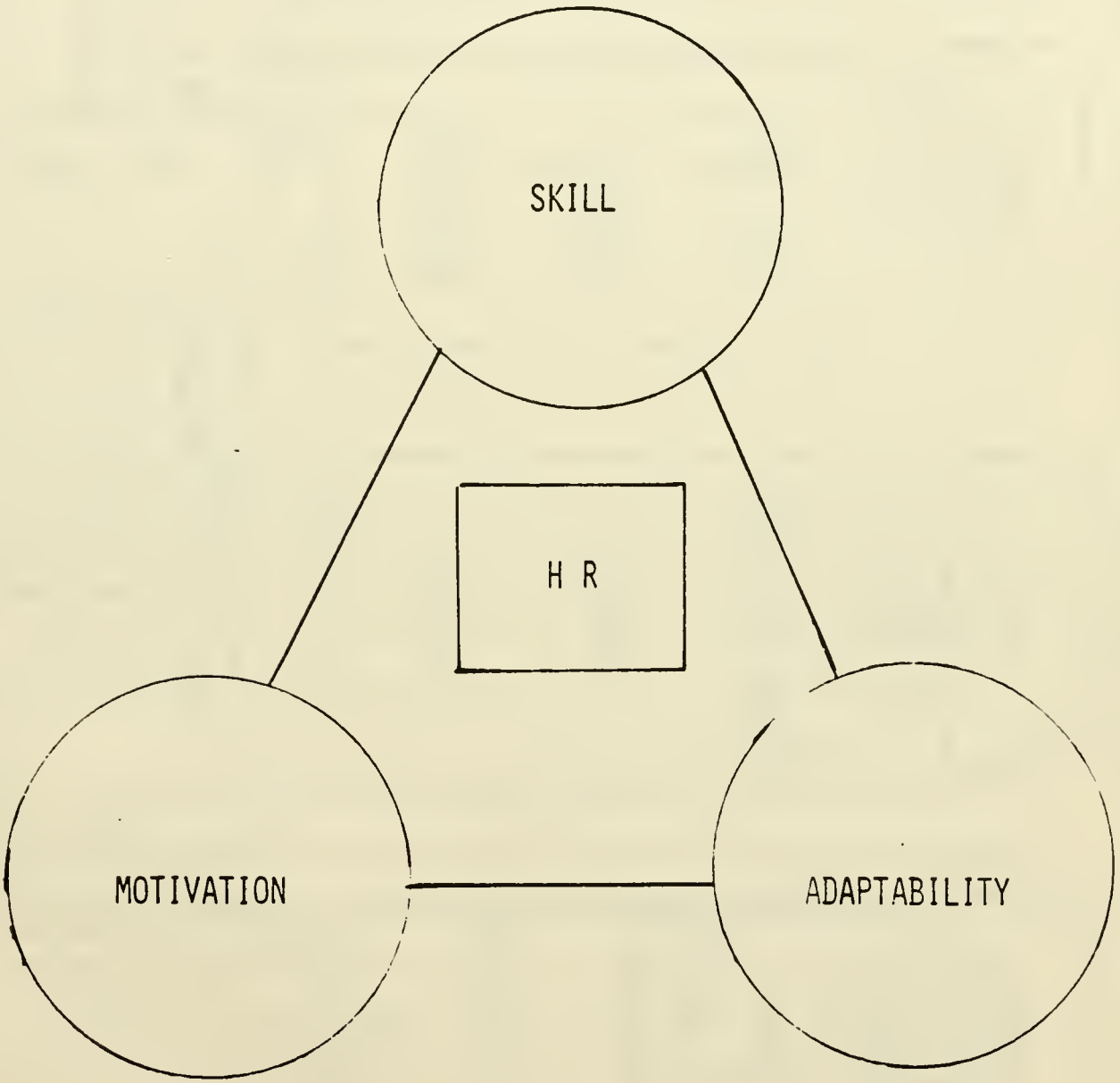
Japanese corporations have developed a well-integrated system of human resource management and industrial relations over the course of the industrialization process, particularly during the postwar period of industrial development. Let us review the essential features of this system, as shown in Figure 4.

Figure 4 about here

In terms of human resource management and industrial relations policies, we may identify four major areas of organizational

FIGURE THREE

DETERMINANTS OF HUMAN RESOURCE EFFECTIVENESS



JAPANESE MODEL OF HUMAN RESOURCE MANAGEMENT AND INDUSTRIAL RELATIONS

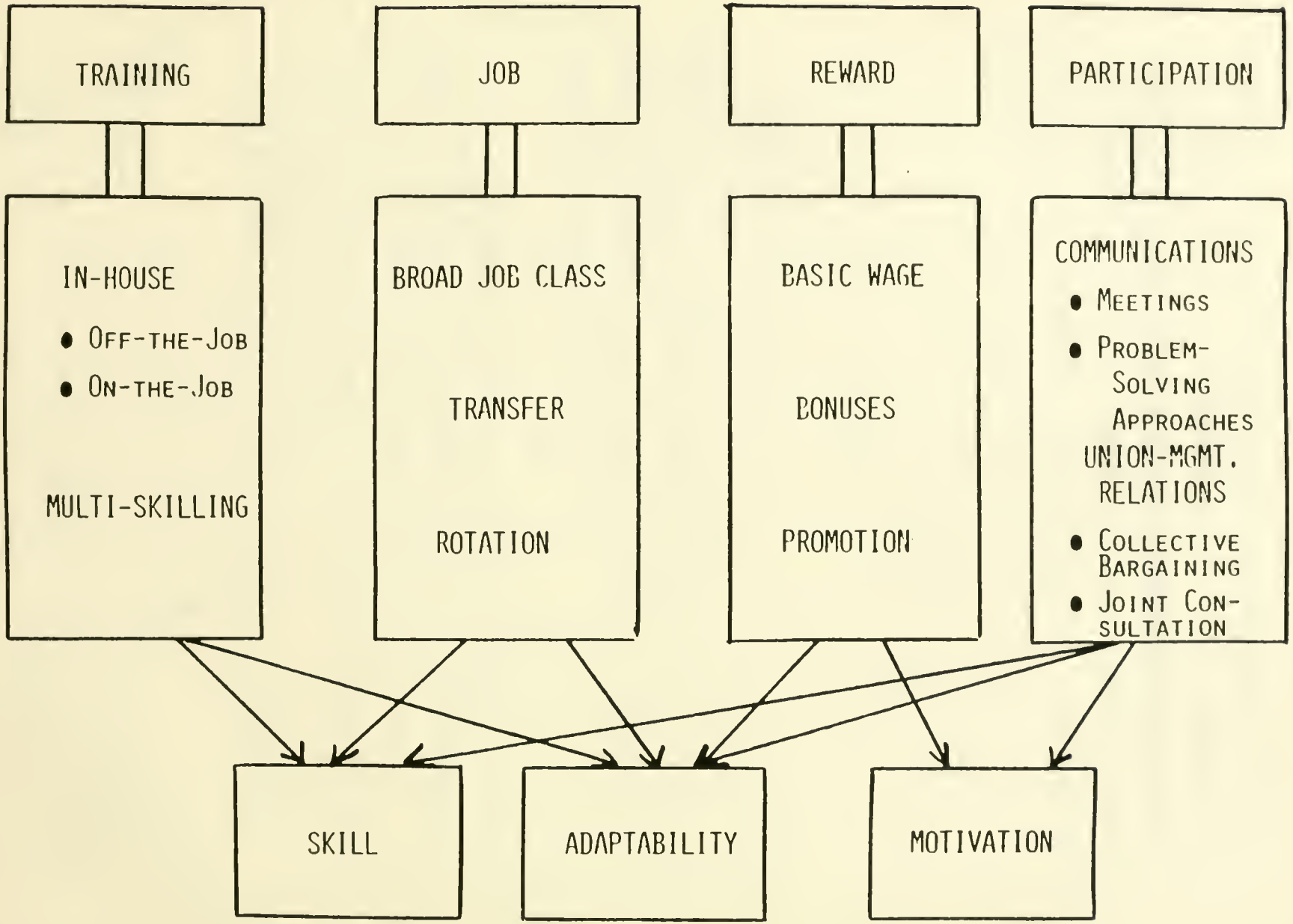


FIGURE FOUR

arrangements and policies. They are: recruitment and training, job structure, reward systems, and participation. Let us review briefly the salient features of each in turn.

1. Recruitment and Training

The recruitment process for Japanese companies benefits from the strong Japanese educational system, which provides a consistent level of basic skills; close links between schools and companies, which permit the identification of promising students and immediate hiring following their graduation; and a relatively homogeneous population of potential employees. Nevertheless, the selection of employees is given close attention, with extensive interviews, both group and individual, and testing of basic skills preceding hiring decisions. The most important attribute sought by employers is the "trainability" of applicants, which refers to the attitude towards learning skills and moving flexibly among different jobs. Job-specific skills are almost always taught to new employees, rather than being sought through the recruitment process.

In-house training is the primary emphasis. While Japanese corporations have developed extensive programs of off-the-job training, on-the-job training is considered more important. This is partly because the Japanese model of humanware requires the close involvement of workers in actual production processes in order to learn necessary skills and become an effective element of the production system. In addition, workers are expected to advance in their careers on the basis of mastery of skills not only in their specific jobs but also for

related jobs within and around their work group. Given the nature of the skill acquisition process, on-the-job training plays a very important role not only in an individual worker's career formation but also in the development of multi-skilled workers. It helps increase the skill and adaptability of human resources, as shown in Figure 4.

On-the-job training in Japanese companies means something quite different than in the U.S., where it tends to mean short, informal and often inadequate instruction from a co-worker in lieu of more advanced training. Japanese companies often have engineers or experienced production workers in a full-time training role on the shop floor, available to help newly-hired team members, or to provide consultation and instruction during a machine failure or other problem. Team leaders also have this training role. A focus on learning through experience characterizes the approach of Japanese companies to on-the-job training.

2. Job structure

An outstanding feature of the job structure of Japanese companies is the absence of the rigidly and rigorously structured job classification system found in American companies. The Japanese companies do of course have similar jobs to those in American companies, because the basic production tasks are similar. The difference, however, is that in the Japanese system, job demarcations are much less rigidly defined and the job classification system is not closely linked to wage rate differentials. The job structure typically consists of a single broad job class covering a wide variety of tasks and

responsibilities, in contrast with the 50-100 classifications found in many American plants.

There are at least two major reasons why Japanese companies have adopted a single broad job class system, one cultural and the other technological. The cultural reason is that Japanese companies in the postwar period have consistently emphasized a classless corporate community, where every employee is treated on a presumably equal basis and no class-related status differentiation is tolerated. In sharp contrast to their labor practices in the prewar period, Japanese corporations after the war abolished, due largely to union pressures for "democratization", intra-organizational status discrimination between managerial, supervisory and production employees in such areas as the pay system, fringe benefits, uniforms, dining rooms and access to other corporate facilities. Japanese companies now regard this classless organization as a highly important factor in promoting sentiments of loyalty, belonging, togetherness, commitment, and other aspects of employee motivation.

However, the more important reason is technological. Elimination of rigid job classifications is meant to prepare all workers to accept whatever job assignments were needed to respond to and meet the technological needs of production management. In other words, the underlying intention is to take full advantage of the versatility of job assignments that a broad job classification can provide. Needless to say, all workers do not perform an identical set of job tasks or receive the same wage rate in Japanese plants. Depending upon the specific

needs of production, workers are assigned to perform different jobs. Wages are then differentiated among individual workers reflecting their personal attributes, job assignments and performance, as will be discussed later.

Career formation and skill development occurs in a way that takes advantage of this job structure. Most notably, Japanese companies utilize extensive rotation and transfer of workers across different but related job assignments. Rotation to different jobs occurs typically within a team or work group. Although rotation is carried out at more or less regular intervals, the timing depends upon the nature of the job and also a worker's mastery of the necessary skills.

Workers are also transferred across work groups, for two reasons. One reason is the adjustment of workforce allocations to reflect changes in volume or production structure, and the other is to assist in the career development of workers. Companies utilize different types of transfers depending upon their needs. Transfers within a period of less than a few months are regarded as short-term and temporary. Short-term transfers for a few days to several weeks are extensively utilized even at normal times as a means of temporary relief. In contrast, long-term transfers are mean a permanent change in a worker's affiliation. All these practices serve dual purposes: making workers multi-skilled and helping them build their occupational careers on the one hand, and providing the company with flexibility and versatility in allocating its workforce on the other hand.

As shown in Figure 4, job structure and policies such as these contribute to the development of skills and the adaptability of the workforce.

3. Reward systems

There are at least three important components which need to be spotlighted in the complex Japanese reward system: monthly regular pay, bonuses and promotion.

Monthly pay makes up the major portion of take-home income. In Japanese companies, all employees formally receive monthly pay. There is no essential status-related distinction in Japanese companies between salary and hourly paid workers as there is in American companies. Monthly pay consists of regular straight-time pay and overtime pay. The rate of monthly pay is determined according to three major criteria: length-of-service, educational level, and job status. Given these criteria, the rate of monthly pay does vary among individual workers, while the distribution among workers depends heavily on the particular pay system. The level of monthly pay itself is the single most important item dealt with during collective bargaining.

Bonuses are paid in most companies twice a year, comprising for most workers roughly one third to one quarter of their annual take home income. The bonus reflects corporate as well as individual performance. Although the average level of bonuses per workers is also addressed through collective bargaining, where the profitability of the

corporation is a major variable, bonuses for individual workers vary reflecting group productivity measures and individual measures such as attendance records. Given the nature of bonuses, they can serve as a means of cost adjustment for the employer, while acting as a motivator for workers. It may be noted that since bonuses have become an important part of the annual earnings of workers they cannot and in fact do not fluctuate as much as one might think.

Promotion is a quite important, though often ignored, element of the entire reward system. Promotion decisions are made usually on the basis of long-term and careful monitoring of workers' performance, and thus have a major motivational effect. This factor serves as an important element of motivation as well as pressure. Monitoring incorporates a wide variety of information over a long period of time, including production performance, attendance, creative contributions, participation, and so forth.

Reward systems such as this presumably not only affect worker motivation significantly, but also facilitate the adaptability of workers because wages are not affected much by transfers or rotation among different job assignments. To the extent that scheduled transfers are used as an instrument for worker's career formation, the promotional reward may well promote greater adaptability of workers.

4. Participation

Two aspects need to be emphasized in participation policies:

communications and union activities. In other words, in Japanese corporations, participation is emphasized through extensive information sharing on the one hand, and through the union's voice on the other.

Communications among various groups of employees and managers as well as within groups are promoted utilizing various formal and informal channels and forums. Meetings are extensively used, including formal and informal, regular and irregular meetings, from morning meetings to quality circle activities at all levels of the organizational hierarchy and among all functional groups. Bulletin boards are extensively utilized. Production, quality, and other relevant information is monitored, compiled, and displayed extensively.

Information is shared not simply for the sake of sharing, but in order to solve problems efficiently and effectively. As we pointed out earlier, the basic premise of the Japanese model of production is to identify and uncover problems as soon as possible. Communication and information sharing is stressed to facilitate joint problem-solving by those with the relevant skills and knowledge -- production workers, supervisors, engineers, and other support staff.

Union activities are another critical aspect of participation in the Japanese production system. Since management cannot force workers to be motivated, the union holds an important key to the success or failure of the system. If the union is antagonistic, the production system will not work because workers as union members will not follow managerial direction. If the union cooperates with management as a

partner, workers will willingly participate unless union leaders have lost touch with their members. Unions can also function as an important channel to diffuse information. With union cooperation, information can be shared more extensively and effectively.

There are two principal organizational arrangements through which unions share information with management and express worker interests. One is collective bargaining. This is where management and the union bargain over basic working conditions such as rate of pay, fringe benefits, working hours, and so on. The other is joint consultation. Virtually all Japanese major companies have this system side-by-side with collective bargaining.[18]

During joint consultation, a wide range of issues are discussed between management and the union, including not only items directly related to working conditions but also broader issues pertaining to general corporate performance and planning. Joint consultation meetings are held regularly at the corporate level, the plant level, and on the shop floor. In many cases, functional committees are formed as an adjunct to the joint consultation process. For example, production committees involve management and union experts in discussions of specific production planning issues.

The union also keeps a close eye on the transfer of workers. While short-term temporary transfers can be carried out by management with post-hoc union approval, long-term or permanent transfers cannot be

made without previous consultation and agreement, at least implicitly, with the union.

All of the major Japanese auto companies are unionized. It is hard to conceive of the Japanese production system operating effectively without the understanding, endorsement, and cooperation of the enterprise unions. Given the extensive involvement of the union in the day-to-day operations of the production system, we can say that the support and cooperation of the union is critical to the system's success.

Participation policies, as expressed in information-sharing activities and union involvement in the production system, are critically linked to all three dimensions of human resource effectiveness: motivation, adaptability, and skill formation.

G. Summary: A "Fragile" Production System

From the "humanware" perspective, the Japanese production system can be characterized by a high interdependence between hardware technology and human resources, which requires a highly skilled, adaptable, and motivated workforce, and an extreme vulnerability to human variability. If human resources do not contribute effectively to the production system, it will not only operate improperly but may actually collapse. In this sense, it can be described as a "fragile" production system.[19]

By contrast, the American production system can be described as "robust" in its approach to humanware, since it is organized in order to make it relatively unresponsive to human variability. This contrast will be explored further in Section III, which traces the development of the "humanware" characterizing Japanese and American production systems.

The key features of the Japanese production system described here are not found in exactly the same form in different automobile companies. Toyota Motor Company initiated many of the better-known innovations such as "kanban" and the "pull" system of scheduling. Meanwhile, Nissan and Honda developed their own approaches to production.[20] Gradually, however, Toyota's production methods have diffused to the other auto companies, perhaps because of Toyota's competitive success. As a result, it is accurate to assert that the basic dependence of the Japanese production system on human resources and the resulting fragility, described above, is characteristic of all the Japanese auto companies.

Also common to all the companies is the approach to developing human resource effectiveness. This approach to human resource management, per se, is hardly unique to Japan. Some observers have noted that careful recruitment, ongoing on-the-job training overseen by experienced co-workers, a job structure which encourages the development of multiple skills and flexibility, individualized compensation, and open communications and receptivity to employee suggestions have long characterized the treatment of middle-to-upper-level white collar employees in the U.S. and Europe, as well as Japan.[21] What is unique

and unusual is to find this approach to human resources applied to blue-collar, industrial, "unskilled" workers.

Our analysis in this section suggests the technological and competitive imperatives that lie behind the kind of "humanware" found in the Japanese production system. The next section will explore the historical roots of this phenomenon.

III. THE DEVELOPMENT OF "HUMANWARE"

A. Japanese and American Models of "Humanware" Contrasted

As explained in the preceding section, the Japanese production system depends fundamentally on human resource effectiveness. The Japanese system can be said to be "fragile", in the sense that it is highly vulnerable to human variability.

This dependence on human resources has both advantages and risks. In a positive direction, it can take advantage of the capabilities of human resources to create a flexible production system which achieves high levels of productivity and quality. However, this linkage can have negative consequences as well. The performance of the system can be disturbed by the malfunctioning of the coordination between human resources and hardware.

Japanese managers are known for their emphasis on trust and respect, human potential and dignity, collaboration and mutual help of employees through team work, and management-labor cooperation. They do so not because they are Confucianists or particularly humanistic in orientation but rather because their production system's successful performance hinges upon human resource effectiveness. What they preach are not cliches, but rather are a matter of survival for management as well as workers, since the livelihoods of both depend on the well-being of the company.

The American production system, in contrast with the fragile Japanese system, may be described as "robust". It can protect itself against defects of materials, disturbances in the production system, errors of the workforce, and other problems.

The system protects itself against hazards or disturbances by resorting to large buffer stocks of materials, parts, and work-in-process. If any supplied materials are defective, or problems occur at any particular work station, the system can maintain production without being seriously interrupted since the necessary flow of supplies can be drawn from buffer stocks accumulated at various stages of the process.

In sharp contrast to the Japanese production system, the extent to which human variability can affect production is minimized. Jobs are finely divided, and work methods are precisely and rigorously determined by industrial engineers. Workers, mostly semi-skilled and unskilled, can often carry out these narrowly-defined jobs with little or no special training.

Carrying out production with large buffer stocks is obviously costly. However, if the producer can take advantage of economies of scale through high volume production, the cost disadvantage per unit of output of large inventories can be minimized. Indeed, this production strategy of combining sufficiently large buffer stocks and high volume production has been the dominant mode for major American auto producers.

The conventional American production system is thus quite well-protected against problems and disturbances stemming from human resource ineffectiveness. However, ironically, it can not for this reason take advantage of the potential productivity and creativity of fully-utilized human resources. These are the limits of the humanware contained in the conventional American production system.

The conventional system has worked well when the American industry has enjoyed a large volume of demand and dominance in the domestic market. Under these market conditions, this type of humanware can accommodate conventional industrial relations practices and perform effectively, and this has been the case for the American auto industry throughout its history, until recently.

B. Development of the Japanese System of Production

The question before us then is why Japanese auto makers developed such a fragile and potentially vulnerable system, so dependent on volatile human resources? What needs were they trying to meet? To understand these questions, there are several historical factors which we must review.

The Japanese automobile industry began its development in the 1930's, largely by transferring technology from the U.S. After World War II, the automobile industry was reconstructed and began a new phase of development. Here again much guidance and technical assistance was provided by the American automobile companies, though to varying degrees

and following different arrangements among different companies. While some Japanese auto makers had licensed production arrangements with American companies and others followed a more independent course of development, it is undeniable that all had to rely on either the explicit or implicit transfer of technology from the American industry, at that point the most developed in the world.

While the Japanese industry was able to gain technological know-how by learning from the advanced American model, it was clear that Japanese industry would never be competitive in world markets by following in American footsteps. Many Japanese automotive entrepreneurs, policy planners, and engineers were aware that a different path of development would have to be pursued. They sought various strategies to overcome this constraint. At the same time, the Japanese companies were at a particular disadvantage in two critical areas: productivity and quality control. These disadvantages had to be overcome for the Japanese industry to gain independent competitiveness.

1. Productivity Inferiority

A large productivity gap existed between the Japanese and American auto companies in the early stages of development of the Japanese industry. This gap, due primarily to the advanced technology of the Americans, was so large that it could not possibly have been narrowed by the Japanese refinement of American production methods. Moreover, the American industry had a definite advantage over the Japanese industry

because it could exploit economies of scale made possible by its large domestic market.

While Japanese auto makers relied greatly on the American pattern of technology up to the early postwar period, some companies gradually diverted from it and developed their own unique production systems, concentrating on saving costs by eliminating redundancies.[22] The leading and most notable example of this innovation took place at Toyota Motor Company, led chiefly by an ingenious engineer, Mr. Tai-ichi Ohno. Ohno focused on developing a production system which allowed inventories to be reduced to an uncomparably low level relative to American practice, thereby gaining a competitive cost advantage. The model of the Japanese production system, as described earlier, emerged gradually through the painstaking efforts of Toyota and other companies that followed its lead.

2. Quality Control Problems

Another disadvantage from which the Japanese auto industry, as well as other Japanese manufacturing industries, suffered in the early stages of postwar development was the low and unreliable state of quality control. Since that time, Japanese industries have made strenuous efforts to improve quality control, relying heavily on the guidance and advice of American experts. However, the methodology that they developed differed considerably from the typical American approach.[23] The most notable difference is that Japanese companies involve line workers in the systematic program of quality control,

whereas American companies tend to resort to experts. This difference may have emerged because of the relative absence of a necessary stock of quality control expertise in the Japanese industrial sector.

Whatever the reason, this unique development of quality control methods has provided some significant advantages to the Japanese production system. One is that quality control has been ingrained deeply and thoroughly in the production process itself, and integrated into the jobs of workers, instead of being left to experts. The other is that the concept of quality control has grown and expanded beyond the realm of the manufacturing process to entire fields of corporate activity, from product design to sales. The significant implication of this development is that the Japanese system of quality control, like the production system as a whole, relies heavily on the active participation and involvement of the workforce.

3. The Transformation of Industrial Relations

The development of the Japanese production system, which evolved under certain economic and technological restraints, has thus come to rely critically upon human resource effectiveness. This process of development had significant implications for Japanese industrial relations. To assure the survival and continuous improvement of their production systems, Japanese corporations have had to secure full support and cooperation from their unions. In fact, when the Japanese production system was in the early stage of development, many companies experienced severe conflicts in industrial relations. Some of the labor

disputes threatened the survival of the companies. This labor turmoil was not only limited to the automobile industry. Many basic industries, such as iron and steel, ship-building, and electrical appliances had similar problems. However, after the mid-1960's, industrial relations in Japanese basic industries began to be transformed from a confrontational mode to a cooperative mode.[24] In this mode of cooperative industrial relations, Japanese unions have played an integral role in running the Japanese production system as an indispensable partner to management, up to the present day.

4. Unique Social Infrastructure

The "humanware" of the Japanese production system has also taken advantage of some other infrastructural factors of Japanese society and its economy. For instance, the well-structured public education system and the well-disciplined and relatively homogeneous labor force fostered through the education system may have helped Japanese companies develop a production system which relies heavily on the effective contribution of workers. The existence of a highly group-oriented network of multi-tier suppliers, which grew out of the traditional Japanese industrial community of small firms, has certainly been helpful for Japanese auto companies in extending their just-in-time production system. Humanware technology in the Japanese auto industry has developed into a total entity of multi-dimensional complexity.

It is extremely interesting to ask whether or not this Japanese model of "humanware" can be transferred into full-scale industrial

operations on American soil, and how such a transfer can take place. The next section will introduce some of the recent experiences of Japanese automobile companies investing in the United Stages in order to get some insights to this question. However, before we move on, let us summarize briefly the major factors which gave rise to the American model of production and humanware.

C. Development of the American Production System

The American production system is characterized by the logic of mass production -- large volumes of standardized goods produced with highly specialized resources. Several factors helped the mass production model flourish in the U.S. First was the huge American market. This market only came into being when the development of a national network of railway transportation unified regional markets in the late 1800s, although it also depended on consumer acceptance of standardized goods. Second was the gradual development of manufacturing expertise, particularly from the mid-1800s until the early 1900s, including the development of machine-made interchangeable parts, the use of a sequential production process, the development of specialized production equipment, and various improvements in coordinating the flow of production. Third was the mastery of managerial and administrative skills needed to apply this manufacturing expertise to the high-volume production of complex standardized goods, such as the automobile. It is in this area that Henry Ford's contributions most properly belong, including the specialization of labor inputs through the simplification of tasks, and the development of elaborate coordination mechanisms for

bringing a vast array of parts and sub-assemblies together in the integrated assembly line.[25]

Over time, the mass production model for the automobile industry developed still further, with assembly plants widely dispersed (in order to facilitate distribution to the national market) and supplied by a few large-scale parts production centers exploiting economies of scale. This development was facilitated by the ready availability of land for production facilities; by low energy costs, which together with a national rail system, kept transportation costs low enough to justify the shipping of intermediate parts; and by low capital costs, which encouraged investment in more and more specialized production technology -- all areas in which the U.S. had relative price advantages over Japan and other countries.[26]

The evolution of U.S. industrial relations is closely linked to the role of labor in the logic of mass production. Labor is viewed as one of the resources needed by the production process, which must be allocated efficiently. The specialization of the labor input means standardized tasks are rigidly defined, so they can be performed by any worker with minimal skills. In this way, workers are interchangeable and replaceable, and employment levels can be adjusted according to the needs of production and the level of market demand. Close supervision of production workers would then guarantee the careful coordination of the labor input with other inputs.

As a counter-development to this view of labor, industrial unions were organized. They sought to protect the interests of semi-skilled workers working in large-scale industries by minimizing management discretion through well-defined work rules. Management developed still further its rigorous scheme of job analysis and level of supervision to counteract union attempts to gain control on the shop floor. Such labor-management interactions consequently gave rise to a rigid system of job classifications, task assignments, work rules, and close supervision.

Within this system, labor can certainly protect themselves from discretional abuses of management authority, while management can protect their interests by making sure certain scheduled tasks are carried out without labor-related disturbances. In this way, the industrial relations system complemented the American production system quite well.

The fact that American producers dominated their domestic market for so long gave rise to a notion that it was entirely theirs to divide, regardless of demand fluctuations in response to business cycles and changing consumer preferences. Moreover, the fact that they enjoyed technological superiority over foreign competitors appears to have developed the notion that the American industry had reached a technological plateau. This seemed to foster the idea that automobiles had become a mature industry, which gradually reinforced and solidified its institutional inertia.[27]

However, the circumstances under which the conventional American production system operated optimally have changed gradually but dramatically since the early 1970's. The technological gap between American industry and foreign competitors such as Germany and Japan has narrowed rapidly, and competition within the American market has grown intense. This requires all the competitors to innovate constantly in order for them to retain or build their share of the worldwide market.

The notion that the auto industry had reached its technological plateau proved to be an illusion. With the emergence of a variety of competitors on the supply side and a variety of tastes on the demand side, reflecting increasing consumer affluence, the market has become increasingly diversified and differentiated. It now appears that it may be difficult for the American industry to enjoy continued dominance of its domestic market. The conventional American production system does not seem to fit the current environment. An interesting question for us is to see whether the American industry can change in the face of the stimulus provided by foreign competitors operating both within and outside of the United States.

Our review of the experiences of Japanese companies who have invested in the United States in the next section will suggest some possible answer to this question.

IV. ACTUAL EXPERIENCES OF JAPANESE COMPANIES IN THE U.S.

Now, let us review the actual experiences of the Japanese companies that have invested in the United States, focusing particularly on production operations at their plants. We include in our review both solely Japanese owned and joint-venture plants. Our major interest in studying their experiences is the process and outcomes of technological transfer, particularly the transfer of what we call "humanware".

In this section, let us first review how the Japanese system of humanware has been and is being transferred by Japanese auto companies through their investment and production activities, and then discuss in some detail aspects of human resource management and industrial relations, as they are integral building blocks of humanware technology.

A. Transferring the Japanese production system

We concluded in section II that the key feature of Japanese model of humanware is a production system which relies heavily on human resource effectiveness. The production system, which operates with low buffer stocks and inventory, small lot sizes, and a "pull" system of information flow is supported and reinforced by the effective human control of alert and motivated employees. Let us observe how such critical ingredients of the system are transplanted by each of the Japanese companies.

1. Honda Motor Company

Honda started operation in the U.S.in 1979. They first produced motorcycles, and then started to build passenger cars in 1982. Honda is the first Japanese company to manufacture automobiles in the U.S. In their main plant located at Marysville, Ohio, they were as of the summer of 1986 producing two models, Accord and Civic, at a rate approaching 300,000 cars a year. Their products enjoy the reputation of being one of the highest quality cars sold in this country.

Honda's production system places the highest priority on assuring high product quality. While low inventory is emphasized, they do not employ a "kanban" system.[28] In the Marysville plant, materials are distributed by material handling teams.[29] The "just-in-time" mode of delivery is practiced as much as possible both inside and outside of the plant. However, there are some inevitable difficulties. While some parts are provided by nearby suppliers on a JIT basis, the long distances separating other suppliers from the plant make it difficult to organize a complete JIT system.

One outstanding feature of the plant may be found in its layout. The plant contains 1.7 million square feet, and has a production capacity of 300,000 cars. The operation includes not only welding, painting, and assembly but also stamping and plastic injection molding. Two assembly lines, one for each model, are laid out side by side in order to accomplish highly efficient space utilization. This efficient use of space helps to minimize not only the direct cost of material handling but also the overhead costs of various utilities and administrative activities.

As mentioned above, the Marysville plant contains stamping and plastic injection molding sections side by side with the subsequent process of welding and assembly.[30] This feature, which is commonly found in most Japanese automotive plants, is advantageous in exploiting quick feedback between related sections to prevent problems from proliferating, as discussed in section II. While the plant can and does enjoy economies of scale by producing 150,000 units of each model annually, it also exploits the merits of small lot production. Dies for the stamping presses, for example, are changed several times a day, with an average time of nine minutes. This small lot production with quick die changes contributes both to the flexibility of production and to minimizing defects in the production process.

The most critical element in Honda's technology transfer process may be their strategy of transferring knowledge and skill through production experience.[31] The company has made enormous efforts to make sure that every employee shares in the critical experience of high quality production. Actual experience, not merely the knowledge of how to build a quality car, is emphasized. The method that Honda has used for developing and expanding its North American production eloquently illustrates this point.

Honda started out with a rather small scale operation of motorcycle production. The production pace was rather slow initially in order to make sure that every member of the inexperienced workforce could acquire and share, as a team, exact understanding, skill and

experience of building "quality" into their products. After accomplishing this process of intensive learning on the job, 200 members of the 400 employees of the motorcycle plant were transferred to the new automobile plant. Their working knowledge and experience has then been transmitted and shared gradually with a greater number of new employees. Here again, the process of knowledge and skill diffusion has been promoted very carefully through rigorously sharing actual work experience. New employees were carefully selected, and were added only a few at a time in order to prevent the dilution of production experience in work team operation.

This process of fostering common experience has been supported and aided by several notable policies. One is the use of a "mother" plant. A large number of American employees were sent to a Honda mother plant in Japan to get concrete production experience. Another is extensive assistance of engineers and skilled employees from Japan who have worked together with American employees intensively since the early phases of production.[32] The concept of a team as the integral organizing principle of the entire operation, encompassing not only production areas but the whole corporation and all cooperating supplier companies, contributes greatly to the process of building joint experience.

2. NUMMI (GM-Toyota joint venture)

NUMMI (New United Motors Manufacturing Inc.) was established as a joint venture between General Motors Corp. and Toyota Motors Corporation in early 1983. In September 1983, the letter of intent was signed by

NUMMI and the UAW, setting out the basis for a cooperative relationship between the company and the union. The first car was produced at the end of 1984, and the production pace was gradually built up for full-scale production by early 1986. At full-scale production, the plant is designed to produce at a rate of 200,000 cars a year with approximately 2500 employees working two shifts.

There were some constraints for NUMMI in transplanting the Toyota system of production. One was the utilization of the old GM Fremont plant, and the other was that NUMMI had to recruit most of its workforce from the pool of workers laid-off from the Fremont plant in 1982. This meant that the Toyota production and management systems had to be conveyed to people who already had a lot of experience in the conventional American system of production and industrial relations. In other words, NUMMI represents the first experiment with transferring the Japanese model of humanware into a "brown field" site.

The old Fremont plant had a productive plant area of 2.6 million square feet where welding, painting, assembly, seat production, and repair were carried out. NUMMI modified the layout to eliminate seat production, set up a stamping section, and remodeled the welding and assembly lines. NUMMI uses only one of the two assembly lines set up in the old Fremont plant to produce the Nova (a car design similar to that of the Toyota Corolla). In remodeling the layout and structure of the plant, the primary emphasis was placed on reorganizing the production facilities to facilitate a system of minimum inventories. Redundant space between production stations was eliminated by remodeling some

parts of the assembly and welding operations. The space for repair was drastically reduced on the premise that the Toyota production method will not tolerate as much repair work at the end of the production line as GM. Consequently, space productivity has increased somewhat, reflecting a more streamlined structure of production. However, these modifications of the physical facilities can only facilitate the operation of the Toyota production system to a limited extent, certainly less than could be attained in a new plant. This constraint has undoubtedly curtailed the full transfer of the Toyota method.

At NUMMI, a clear priority has been the transfer of the "invisible" systems which are the organizational core of humanware. Let us describe some of those elements, such as the just-in-time (JIT) and Kanban systems, low inventory practice, standardized work procedures, and continuous improvement ("Kaizen") activities.

The basic framework of the Just-in-Time system has been introduced. The Kanban system has been adopted wherever applicable to realize and promote JIT production. While the Kanban system has been applied systematically within the plant to facilitate the JIT flow of inputs, there remains an obvious limit to applying the system to external suppliers. Some suppliers in the vicinity of the plant, such as a seat producer, deliver products following the JIT procedure, but remote suppliers from Detroit and Japan can not easily satisfy the JIT requirements. Nevertheless, strenuous attempts are made to reduce and minimize inventories in the production process. The plant has achieved

notable results in reducing inventories, and thus reducing costs and increasing productivity.[33]

Streamlining production through the Toyota method relies on the effective and active involvement of production workers. "Kaizen" or continuous improvement effort is an umbrella concept covering the organizing and promoting of improvements which enhance efficiency and improve quality. A cornerstone on which Kaizen activities can be built is the requirement that all workers be able to perform their tasks flawlessly. Unless this requirement is satisfied, Kaizen activities may run a risk of creating chaos and would not serve any purpose.

A useful device to meet this requirement is what Toyota calls "standardized work", in which workers at the workshop are given the opportunity to write up the most appropriate work process by themselves. By participating in this procedure, workers learn the content and meaning of their tasks precisely, master the skills to perform them correctly, and become able to express them systematically as well as to teach them to others. Knowledge, skill, and experience acquired through this process serve as the basis for Kaizen activities which often imply modifications of previously accepted systems and procedures of production. In NUMMI, the basic rules and procedures of standardized work are explicitly stipulated in the collective bargaining agreement.[34] This procedure appears to play an integral role as a organizational device to motivate workers and make them actively involved in production as well as in improvement processes.

3. Nissan Motor Company

The Nissan Motor Manufacturing Corporation (NMMC) U.S.A was established in 1980. That same year, Nissan Motor Company, the mother company in Japan, named Marvin T. Runyon as president and CEO of NMMC. Runyon has taken the lead since then in all aspects of NMMC's corporate activities, ranging from the investigation and choice of plant site, overall plant design and layout, and routine production activities, up to the present day.

NMMC began production of light trucks in June 1983, and about a year later reached a full-fledged production capacity of 120,000 trucks a year. In March 1985, NMMC started to produce a subcompact passenger car, the Sentra. With the introduction of a night shift in 1985 and the major restructuring and expansion of productive capacity in 1986 side by side with major changes of both the truck and car models, the company plants to reach its full two-shift capacity of 240,000 vehicles a year by the end of 1986 with more than 3100 employees.

NMMC's mode of production and management systems may be described as a mixture of American and Japanese ingredients incorporating useful Japanese technological and organizational elements into the American style of management.

Taking advantage of a green field site, a plant with an under-roof area of 78 acres was constructed in a highly systematic way, combining three major buildings to accommodate such operations as stamping, body

assembly, painting, final assembly and other auxiliary activities.[35] This well-equipped plant was designed by an American architectural engineering firm and constructed by an American contractor.[36] Compared to other Japanese-owned plants in the U.S., the layout of NMMC is much roomier and less compact, perhaps reflecting a planned allowance for the future expansion of its productive capacity.

A high degree of automation and the usage of the latest and most sophisticated production facilities is one of the most visible characteristics of the plant. As of the summer of 1986, the plant has 237 robots which operate in such areas as paint and sealants, spot and arc welding, and tire installation. While much of the production facility was designed and built by Japanese manufacturers in cooperation with Nissan Engineering Company, American and European manufacturers also provided many important pieces of production equipment.[37]

The production system incorporates many features of the Japanese production system. Stamping and assembly are carried out under the same roof, which facilitates quick and effective feedback between related production stations, as discussed in Section II. The pull system of information is adopted wherever applicable, making use of the "active plate method", or APM, which resembles Toyota's Kanban system. Although the plant is highly integrated, carrying out operations from stamping to final assembly, it also relies heavily on outside suppliers.[38] While some critical components such as engines and transmissions are supplied from Japan, 45-50% of the overall parts are supplied by American manufacturers (as of the summer of 1986).

At NMMC, management and production activities are carried out mostly by Americans. Intensive efforts were made during the early stages of operation to transfer knowledge, skill and experience from Japanese advisors. But as experience has accumulated at NMMC, the presence of Japanese personnel in management, engineering, training, and other staff functions has been reduced substantially, leaving only a handful of advisors.[39] Under the leadership of Mr. Runyon, the company maintains a relatively compressed organizational structure with around five hierarchical levels. Human resource management systems and practices are impressively well-organized, as we will discuss in more detail later.

4. Mazda Motor Company

Mazda set up a U.S. company, Mazda Motor Manufacturing USA Corporation (MMMUC), in early 1985. MMMUC soon launched construction of the plant in the midst of the Detroit industrial area, the city of Flat Rock, Michigan. The plant is modeled almost exactly after its sister plant in Hofu City, Japan. The plant of 2.2 million square feet, representing a total initial investment of 450 million dollars, is designed to take advantage of the latest technology and of compactly designed production facilities. Mazda plans to produce its first car by the fall of 1987. When the plant reached full production, it will have a productive capacity of 240,000 compact cars a year, and approximately 3500 employees.

MMMUC will also attempt to introduce the production system which Mazda in Japan has developed over the past few decades. Mazda's production system is quite similar to that of Toyota. Emphasizing the principal targets of high quality and low cost, the system includes such key elements as JIT production, low inventory, low redundancy, and the utmost reliance and utilization of the innovative and creative participation of workers in production processes.

Soon after its establishment, MMMUC recruited key managerial personnel here in the U.S. in such areas as personnel and production management. The company started recruitment of supervisory and production employees in the summer of 1986 and began training in preparation for launching production in 1987.

5. Summary

Our review of the experiences of five Japanese companies in transferring their models of humanware suggests the following points.

The transfer of humanware may be examined in three interacting sub-areas: 1) aspects of hardware technology, such as actual production equipment and the design and layout of production facilities; 2) the production system itself, in terms of controlling the flow of information and goods and organizing the deployment of human resources; and 3) the uses of human control in production activities, particularly its adaptive and innovative aspects. In all these areas, Japanese companies have attempted to transfer their approach to humanware.

In the area of hardware, both in terms of plant layout and design and equipment installation, Japanese managers have implemented the basic features of their model. This is reflected in the installation of stamping facilities near assembly lines, and the layout of machines in a way that minimizes in-process inventory and allows the utilization of multi-skilled workers. This transfer has been quite successful, and has in some cases been carried out using American-made machines and American engineering and construction firms.

The production system is largely invisible. Nevertheless, we can see clear trends that the pull system of information, small lot production, the JIT system, low inventory practices, a strong supplier network, and work organization which allows for close communication and teamwork are being used. In some companies, the use of these methods is more explicit than in others. Notwithstanding the strong emphasis placed in all companies on pursuing low cost and high quality production by mobilizing all or some of these methods, there are still limitations to their use in the U.S. at this time. For example, while the system of JIT delivery is established, it is difficult to implement it completely because of the absence of an intensive network of suppliers in the vicinity.

Human control is emphasized, and necessary steps are taken to equip employees with a full understanding of the role of human control as well as the relevant knowledge and skill to exercise it. Intensive education and training, the accumulation of experience through joint

problem-solving, and the encouragement of continuous improvement efforts are some of the steps taken to achieve this goal. However, whether this aspect of humanware has been developed sufficiently to provide the system with a capacity for self-generating innovation, a critical feature of the Japanese humanware model, remains to be seen.

B. Transferring Human Resource Management Practices

1. Recruitment

Japanese plants in the U.S. place a strong emphasis on recruitment and make enormous efforts to select the desired type of workforce, although the specific mode of recruitment varies among different companies.

Honda's recruiting approach has been careful and consistent. Honda started its operation with motorcycle production in Marysville. Marysville is a rural farming area remote from the industrial centers of Ohio. After setting up a team of key managerial personnel, Honda started to recruit a small number of workers from the local labor market. Most of them were young, inexperienced workers without previous manufacturing experience. Those who did have manufacturing experience had mostly not worked in the automotive industry before. In the two years following the 1979 opening of the motorcycle plant, the workforce reached the level of 400 people, and many close-knit relationships developed because of this small size.

Soon after motorcycle production began, Honda announced plans to build a major passenger car plant on the same site. To build a workforce for the new plant, about 200 core employees were pulled from the motorcycle plant so their production experience could be diffused and the remainder were selected gradually through a careful, multi-stage process. This care was necessary to allow each new worker the opportunity to master the skills needed for quality production. As a result, it took a few years to build the auto plant workforce to its current level of 2500 employees.

Nissan set up the plant in Smyrna, Tennessee, a rural farm town some 15 miles away from the state's major commercial center, Nashville. The company recruited the necessary workforce from the local labor market, an area known for its solid work ethic. Thanks to the publicity and relatively superior working conditions offered by Nissan, more than 130,000 applications were filed for some 3,000 job openings. The company carried out its selection and recruitment activities working together closely with the state government. One unique feature was that applicants who passed the initial screening of their application forms, were provided the opportunity to attend a pre-employment training program that was partially supported by the state and jointly run with the company.[40] During this program, applicants receive training in the basic skills needed for various jobs, with the amount varying depending on their expressed preferences for jobs and the previous experience of the individual. The company selects the final group of employees from those who have completed this training course. Further job-specific training is given following formal hiring.

NUMMI went through a unique process of recruitment unlike that of Honda and Nissan. As part of an implicit agreement with the United Auto Workers (UAW), NUMMI had to recruit its workers from the group of laid off employees of the old GM Fremont plant. The old Fremont plant had employed at its peak some 6,000 workers. Due to the shutdown of the plant in 1982, most of them were laid off. Some of them stayed in the local area around Fremont, and other moved temporarily or permanently to other areas, often to other GM plants. After the company was established, NUMMI personnel managers and staff started the recruitment process, working closely with ex-union officials from the old Fremont plant. In fact, these former union officials played a key role in screening and selecting the 2,500 new workers from the pool of 6,000.

Mazda started to recruit its workforce in the summer of 1986. Since the location of the plant is in the center of the Detroit industrial area, many of the applicants quite naturally have considerable experience in automobile or auto parts production and many of them are union members. The recruitment process has been nearly continuous, with only a small group of employees, perhaps a few dozen, are hired at any one time. The company plans to hire about 3,000 workers in the first year.

In summary, recruitment and selection by the Japanese companies generally appear to have two salient features: the recruitment process itself, and the selection criteria used.[41] Normally, the recruitment process involves such steps as screening by application forms, group

interviews, examination of vocational skills and other relevant aptitudes at assessment centers, and individual interviews. The process of such a series of screening can often extend for several weeks. This kind of careful recruiting is often observed for managers and engineers in the U.S., but is almost unheard of for production workers.

The single most important criteria in this selection process seems to be the attitude and aptitude of workers towards teamwork. In other words, whether workers understand or are willing to understand the importance of working together, helping each other, and sharing information is the major concern of Japanese management.[42]

A comment is in order for the recruitment of managerial staff. In most of these companies, managerial positions related to financial matters are held by Japanese managers, while personnel management, industrial relations, and production or manufacturing jobs are filled by American managers. In the selection of managers, Japanese companies seem to place the utmost emphasis on how well the candidates understand (or are willing to understand) Japanese management policies and production methods, particularly those related to the concept of "teamwork" at all levels, from the shop floor to relationships with suppliers. These managers are also carefully selected from many applicants, and often come from outside the automotive industry. Even in the case of joint ventures like NUMMI and the Chrysler-Mitsubishi effort known as Diamond Star, most line managers in the human resource and production areas are recruited from outside except for those sent directly from the American partner company for special training.

2. Training

Training is another factor which Japanese companies in the U.S. emphasize greatly. Training provided to workers is an intensive and long-lasting process. Training is given in several forms: preliminary vocational training, orientation sessions, introduction to Japanese "mother" plants, and on-the-job and off-the-job training.

Nissan asks inexperienced workers to go through preliminary vocational training as a prerequisite for employment. This program provides future employees training lasting from 16 to 360 hours, depending on the area of specialization and the worker's background. The state government of Tennessee provides financial support to this program.

Employee orientation is emphasized by all these companies. Incoming employees are oriented in special sessions lasting anywhere from several days to a few weeks. Through these sessions, the companies attempt to teach the basic concepts of their production system and management style.

A substantial proportion of employees, ten to fifteen percent in both supervisory and production jobs, are given the opportunity to visit plants of the "mother" company in Japan. Honda sent 150 employees to Japan for intensive training prior to opening the auto plant in 1981. Nissan sent 380 supervisors and production workers to Japan in

preparation for beginning truck production in June 1983. Their production workers spent on average six weeks acquiring on-the-job experience in Nissan's Japanese plants, with supervisors receiving more extensive training through multiple visits to Japan. NUMMI, following its orientation sessions, sent about 300 employees to Toyota's Takaoka plant for several weeks of training.[43] Mazda began sending employees to its Hofu plant in the summer of 1986.

During these training visits, American workers learn Japanese methods of production operation by observing and working with their counterparts in the "mother" plant. Sending many employees to Japan for a lengthy visit is extremely costly. However, it is considered extremely important and effective training since it gives American workers the chance to experience and learn directly how the Japanese production system operates, knowledge which could not be transmitted effectively with lectures or other classroom training techniques.

In the first few years of a new plant's operation, Japanese engineers and skilled workers from the mother company are stationed in it to teach and consult with American workers on the job.[44] This is another critical part of training activities. Valuing the importance of this joint learning process, Honda still has a sizable number of "staff engineers" (who are actually experienced production workers from Japan) working on the shop floor, even after years of successful production. Nissan, in contrast, reduced the number of Japanese staff rather quickly as American employees accumulated experience in the plant. NUMMI received a few hundred engineers and trainers from Toyota who were, at

the start, involved in actual production activities. However, with the accumulation of production experience at NUMMI, Japanese staff and trainers are increasingly moving out of production responsibilities and into advisory roles.

Training and learning on the job sometimes relates to promotion. Honda, for example, partly because of its process of growth from a relatively small size operation of motorcycle production, has been able to promote young inexperienced workers to positions as high as managers of production departments within a few years. This is the rule rather than the exception at Honda. Most of the current production department managers started as entry level production workers and were steadily promoted as they gained experience. This kind of promotional opportunity tied to learning experiences on the job seems to stimulate considerable employee motivation.[45] However, plants which start with large-scale production from the very beginning and have a relatively experienced workforce, which is more the case for Japanese companies opening plants more recently, normally cannot provide as many promotion opportunities. In those plants, while training is provided intensively and workers are deeply involved, there appears to be fewer hopes or expectations of promotion.[46]

The Japanese plants in the U.S. place extraordinary emphasis on the selection and training of workers for two reasons. First, the Japanese plants in the U.S. are carrying out a major technological transfer process. This requires the voluminous expenditure of resources on education and training for the American managers and workers who are

attempting to learn the Japanese production system. The second and more important reason is the critical role of human resources in the Japanese production system. Since the entire production system depends so heavily on human resources effectiveness, unlike the conventional American production system, Japanese companies need to be extraordinarily sensitive to the personality, preparedness, attitude, and participation of workers. To put it strongly, the selection and training of workers are questions of survival for Japanese companies in the U.S., largely for technological reasons.

Finally, the perceived heterogeneity of the American workforce appears to intensify Japanese companies' education and training activity. The Japanese production system has operated successfully in Japan with a relatively homogeneous labor force in terms of preparedness and motivation. To attain a comparable result with the diverse American workforce may require these Japanese companies to devote even greater resources to training than they do in their home country.

3. Job Structure and the Functioning of the Production System

a. Job classifications

All the Japanese companies now operating in the U.S. emphasize a single broad job classification for production workers. While they do establish a few special skilled job classes as well, the overwhelming majority of workers are classified in the same single job class.

Honda gives all its employees the same general title of "associate". Employees are composed of two basic groups: salaried and hourly wage employees. Managerial and supervisory salaried employees are classified as exempt, and non-supervisory salaried and hourly employees as non-exempt. Hourly wage employees are divided into two broad categories, production associates and maintenance associates, with the great majority in the former category. These categories correspond to a single job classification, which is linked to a single wage scale which has some progression based on length of service.

Nissan has a similar system, with all non-exempt employees called "technician". Technicians are classified as either "production" or "maintenance" with a single wage scale attached to each group.

NUMMI also has broad job classifications. The classification scheme and corresponding wage rates are stated clearly in the collective bargaining agreement.[47] There are three job categories for non-exempt employees, who are called "team members". They are production, tool and die, and general maintenance, and each has a single wage scale with some progression related to length of experience. Mazda is also planning to adopt a similar job classification scheme.

As stated earlier, the major reason why Japanese companies adopt this kind of broad job classification system is to take advantage of the high degree of versatility of job assignments. In contrast, in conventional American assembly plants, job structure is finely classified into up to 200 key jobs which are then rigorously linked to

different wage rates. While such an American job classification system is advantageous in the sense of making job and task demarcations clear for both workers and managers, it certainly is disadvantageous in the sense of sacrificing the adaptability of work organization to changes in production technology. Broad job classifications are considered more advantageous technologically because they can enhance organization flexibility and increase efficiency by minimizing intra-organizational mismatches. It is also advantageous sociologically in the sense that it can enhance the feeling of equality among employees, which is helpful to cultivate a philosophy of mutual help and teamwork across different occupational and organizational boundaries.

While corporations in Japan have been taking advantage of this approach throughout the postwar period by abolishing intra-organizational class differentiation almost completely, Japanese companies in the U.S. still have not abolished the differentiation between salaried and hourly wage employees, and between exempt and non-exempt. This intra-organizational status differentiation, which is deeply rooted in the American social structure, may exert some significant influence on organizational adaptability and employee motivation in the long-run by constraining the extent to which the differentiated employees share goals, information, and experience.

b. Teams

The team concept is strongly emphasized by all the Japanese companies operating in the U.S. This is perhaps the single most

important concept in the management of production activities in Japanese corporations. The concept encompasses not only the operating teams at the workshop but also the entire corporate organization, and even extends to include the network of supplier companies.

The thrust of the team concept is "togetherness" in the sense of working together, helping each other, and sharing information. The operating team usually consists of 5 to 10 team members led by a team leader. In the case of NUMMI, the team leader is a union member and a non-exempt hourly wage employee.[48] The role of team leader is critical to making the team operate effectively. The team leader is expected to have mastered the skills necessary to perform the tasks of all the team members, so that he can show, demonstrate, teach and advise them how to perform the job correctly. While he has some supervisory functions, they are much more limited than the supervisory discretion enjoyed by a foreman in a conventional American auto plant. The team leader's role is more to advise and teach team members, particularly on technological matters, keeping records, and keeping production work going, including working temporary relief for team members as needed.

In most cases, several teams are bundled together to compose a group. The group is led and supervised by the group leader, (called in some instances the group coordinator). In the case of NUMMI, the group leader is not a union member. The group leader or coordinator assumes a greater supervisory function than the team leader. Their role resembles to some extent the foreman at a conventional American plant, although it differs in some important ways.

The concept of team in not unique to Japanese plants. In fact, the team concept has perhaps existed longer in the U.S. than in Japan. In the last decade, there have been several notable attempts in American auto plants to introduce operating teams on the shop floor. In contrast, Japanese companies have never really referred to their work organization in Japan specifically as "teams", although they constantly emphasized working together and helping within work groups. They began to use the term "team" explicitly after they started major operations in the U.S.

The Japanese concept of team seems to differ from the American use of the term in some respects. The American concept of team appears to indicate an autonomous, self-managing work unit, while the Japanese use of the term has much less of this connotation.[49] Instead, the Japanese concept of team emphasizes togetherness, mutual help, and information sharing within the team, and this team concept sometimes is extended to include outside suppliers.

Indeed, this emphasis on mutual help and support is the integral core of the team concept for Japanese companies. The work organization and its functions are designed in such a way that team members, team leaders, and group leaders are supposed to receive full support from relevant functionaries or sub-organizations of the plant or company. They receive assistance on production and other administrative matters not only from immediate supervisors but also from managers and assistant managers of their respective departments, on personnel issues from

personnel officers, on technical issues from line and staff engineers. Constant and intensive support from engineers to workers is particularly emphasized by Japanese management.

The role of the first-line supervisor, which is normally assumed by a group leader or coordinator and to a lesser extent by a team leader, differs somewhat from that of a foreman in a conventional American plant. With the multiplicative support network around them, they have less prerogative over personnel matters than American foremen and consequently have less direct and pointed confrontations with workers than American foremen, while on the other hand they are involved more closely in production operations and improvement efforts with their team members. This mode of mutual help, cooperation and information sharing is extended to encompass the network of cooperating firms such as suppliers. The Japanese companies in the U.S. are currently putting major efforts into developing an on-going working relationship with suppliers to improve the quality and delivery of materials, applying the extended team concept.

c. Rotation and Transfer

The rotation and transfer of workers is viewed by management as an important vehicle to facilitate both structural adjustment of the organization and on-the-job training of employees. Taking advantage of broad job classifications, as discussed earlier, Japanese companies use transfer policies for these purposes.

Rotating workers among different job assignments is carried out in some cases systematically and in other cases in response to day-to-day needs at the workshop. Honda appears to rotate workers to different jobs largely in an ad hoc manner in response to workshop needs rather than according to rules.[50] Nissan appears to have a policy of regular rotation, although the type and timing of rotation varies among different departments.[51] NUMMI also rotates workers regularly, but more in some departments than others.[52]

The transfer of workers is also carried out by Japanese companies in the U.S. All Japanese companies in the U.S. have explicit rules about the transfer options available to workers. But the actual cases of inter-departmental transfers requested by workers appear to be quite few in number. The bulk of transfers occur in response to the structural changes of the company. Honda has been transferring workers frequently for the past few years in preparation for or in adaptation to a series of expansion activities related to the diversification of production facilities. At the same time, workers who have been promoted have been transferred several times in their careers, and thereby exposed to many different aspects of production.[53] This represents a kind of de facto career formation for these individuals, who developed multiple skills through a series of lateral transfers. Nissan and NUMMI have similar transfer policies, but it remains to be seen, because of their relatively short period of operation, whether they will apply these policies in the "career formation" way seen at Honda.

In summary, we may point to the following features. First, all the Japanese companies in the U.S. make use of a broad job classification system with only two or three classes of hourly employees. Compared with the practice in Japan, this approach differs in two respects. First, the emphasis on a single broad job class is more explicit in the U.S. than in Japan. This may have been necessary in order to insure organizational versatility in an institutional environment which typically emphasizes rigid and finely divided job structures. Second, there is an acceptance in the U.S. of an explicit status differentiation between salaried and hourly employees, and between exempt and nonexempt employees which does not exist in Japan, and reflects an adaptation to prevailing American practice.

Second, the concept of team is advanced strongly by all the Japanese companies in the U.S., perhaps more explicitly than in Japan. This again may be a necessary outgrowth of the effort to communicate the value of joint problem-solving and information sharing to American workers and managers molded by social norms of individualism and adversarial labor relations. However, the fact that the team concept itself has long historical roots in the U.S., and is applied in a way that differs from the Japanese approach raises the risk that the emphasis on teams will be misinterpreted.

Third, a career development orientation towards managing production workers, which takes advantage of organizational features which allow flexibility and versatility, appears to be taking hold, although on mostly an ad hoc basis. Whether this practice, which is a

crucial element of Japanese human resource policies, can and will be developed systematically and applied broadly in the U.S. remains to be seen.

4. Reward systems

The reward system in the Japanese model of humanware, as we reviewed it in Section II, had three main components: wages, bonuses and promotion. Since we have touched upon the topic of promotion above, and bonuses of the sort given in Japan are largely absent in these U.S. plants, the focus here will be on wages.

Wages are the major component of the reward system for American workers in Japanese-managed plants. Linked to the broad job classification system, the wage structure for hourly employees is relatively simple.

Honda has basically only two wage scales for its associates, one for the production group and one for the maintenance group. Workers performing up to expectations receive a wage increase every six months for the first year and a half, at which point they have reached the top of the scale.[54]

Nissan also has separate wage scales for its production and maintenance technicians. For both categories, wages are somewhat regularly increased for normally performing employees up to the third year when they reach full-fledged flat rates.[55]

NUMMI has three wage scales for three categories of hourly employees: production, tool and die, and general maintenance. Like Honda, new workers receive wage increases every six months, reaching the full rate after 18 months. Other categories of workers follow a similar progressive scale before reaching their top rate.[56]

This basically flat wage rate system, with some initial progressivity, is distinctively different from the wage system which Japanese companies have adopted in Japan, as discussed in Section II. This may be viewed as an inevitable consequence of adopting a broad job classification system in the American labor market. In other words, as long as Japanese managers insist on a broad job class, a simple flat rate system may be unavoidable. It is worth noting that this kind of wage system is both more egalitarian and more rigid than wage systems in Japan.

It is interesting to speculate about the long-run consequences of this egalitarian wage system for workers' satisfaction, motivation, and management's controlability of employee incentives. In the short-run, workers may well be satisfied for such obvious reasons as the relatively high level of pay for the local labor market and somewhat higher levels of wages for the bulk of workers who received lower wages, comparatively, under the rigid and complex internal wage structure of traditional American plants. However, in the long run, a wage system which cannot provide pay premiums for higher performing individuals, and cannot offer many promotion opportunities may lead to disenchantment in

the workforce. It also removes a set of important incentives from managerial control. Some have suggested that the world of work has entered an era in which workers are motivated by recognition, appreciation, and other non-pecuniary, non-promotional rewards.[57] If this is so, which of these incentives will work most effectively in the long run? If not, what adaptation will these Japanese-owned plants make?

5. Participation and Industrial Relations

As discussed in Section II, communications and labor-management relations are major factors affecting the performance of the Japanese production system. Let us focus here on the actual experience of Japanese companies in the U.S. in these key areas.

Communications and information-sharing are strongly emphasized by Japanese managers operating in the U.S. This is because sharing useful information quickly and effectively among relevant people is considered to be the key to the successful operation of the Japanese production system. The Japanese companies in the U.S. have developed various arrangements and devices to promote information-sharing.

Honda's mode of communication is ad hoc and flexible and yet appears to be highly effective and productive. They utilize extensively daily meetings, both formal and informal, at all levels of the organization ranging from executive managerial meetings to operating team meetings on the shop floor. Written forms of communication are

also used, particularly in a suggestion program known as "Speak Up". NH (New Honda) Circles, a kind of quality circle, also facilitate information-sharing. More importantly, Honda's information sharing occurs less through these organizational structures than as part of daily operations. The phrase "Y-gaya" is often used, in reference to the informal joint problem-solving activity that occurs on an ongoing basis.

Nissan has developed an impressive set of information-sharing arrangements. In addition to meetings at all levels and the use of newsletters and broadcasts on the internal cable TV network, team discussions, or Involvement Circles are encouraged.

In non-unionized plants such as Honda and Nissan, the primary channel of communication is between employees and their direct supervisors. What is most emphasized is that supervisors listen to workers, to identify problems and work together to solve them. This mode of communication is also emphasized in the unionized setting of NUMMI.

At NUMMI, although they have formal collective bargaining and organizational arrangements such as Union-Management Committees, informal discussions at the workshop are strongly emphasized. What is encouraged is fostering an attitude of solving problems through informal discussion prior to filing them as grievances. As a result, formal grievances have been nearly non-existent.

Patterns of industrial relations, particularly with regard to unionization, differ widely among the Japanese companies in the U.S. NUMMI has been fully unionized from the beginning, having started its operation by recruiting members from the pool of laid-off UAW members from the closed GM Fremont plant. Soon after full production began, an election was called to recognize the union and UAW local 2244 was established. Indeed, the ex-union officers of the old local worked closely with the management from the formative stages of the new company, particularly in recruiting workers. Toyota, following this joint venture experience with GM and the UAW, has begun construction of its own plant in Georgetown, Kentucky, a Southern rural community. Toyota's official position on unionization of the new plant is, not surprisingly, neutral, indicating their willingness to let future Georgetown employees choose.

Mazda, which has almost completed construction of its plant in Flat Rock, Michigan, has expressed its clear interest in working cooperatively with the UAW. In fact, the regional UAW office has provided advice and assistance in the recruitment and training activities of the workforce.

Diamond Star Motor Corporation, the joint venture of Mitsubishi and Chrysler, has started construction of its plant in Bloomington, Illinois, and seems to anticipate unionization, although its official position is neutral.

On the other hand, some companies have been staying away from unionization. Nissan, which chose to locate in a conservative Southern rural community, has taken the most explicitly anti-union position.[58] Honda, which is officially neutral on the issue of unionization, has not been unionized despite concerted organizing efforts by the UAW. It claims that only a few employees have expressed an interest in the union.[59]

Varied as they are, the attitudes of Japanese companies towards unionization is hardly generalizable. Their official attitude is unquestionably neutral. Whether their plants will be unionized, however, seems to depend on a combination of factors, such as their relationship with their American corporate partner (in the case of joint ventures), the philosophy or attitude of those local managers who have been delegated decision-making authority, the location of the plant, the degree of unionization of the local labor market, the attitude of the community towards unions, the values and interests of incumbent workers, and the actual or potential relationship of the companies with regional and national union leaders.

In the Japanese production system, as discussed earlier, unions are intended to, and actually do, play an integral role as a cooperative partner in production operations, while filling a traditional advocacy role in the distributive aspect of industrial relations. Apparently, the minimal common interest of Japanese companies is to build cooperative and productive industrial relations with unions in order to reap the benefits of the Japanese production system. Whether

unionization will become common or not in Japanese plants in the U.S. in the long run would seem to depend on how much both management and union leaders will learn from and understand the meaning of their present and future experiences.

V. INTERPRETATIONS AND DISCUSSION

Having reviewed the actual experiences of Japanese investments in automobile manufacturing, let us now interpret our findings and discuss major policy implications. In doing so, we would like to focus our attention in four major areas. They are: A) evaluating the nature and process of technology transfer; B) the long-term issues and prospects for Japanese investments; C) lessons for American industry; and D) lessons for Japanese investors.

A. Evaluating the Nature and Process of Technology Transfer

In discussing technology transfer, our interest is in the broad concept of technology which encompasses both hardware and utilization of human resources, particularly their interlocking interactions as symbolically expressed by our term, "humanware". Let us summarize the experiences of transferring such a comprehensive concept of technology.

First, hardware technology. Almost exact transfers have been made in terms of hardware machines and production facilities. While a considerable amount of production equipment has been supplied by American and European manufacturers, the basic design, layout, and installation of production facilities has been carried out under the strict supervision of Japanese engineering teams, in order to reproduce the essential features of the Japanese production system.[60]

Second, systems of human resource utilization. We mean here those arrangements, devices, and methods by which human resources are utilized in the production system. This may be viewed as the core of the concept of humanware. Japanese companies have transferred several integral components of their approach to human resource utilization in to production systems in the U.S. Perhaps the single most important component is the "team" concept. To realize the objectives of "team" operation, they have introduced necessary organizational arrangements encompassing leadership, supervision, technical assistance and support functions, job structure and reward systems. Also, practices of rotation and transfer of workers across different and yet related jobs have been introduced.

So far, these human resource utilization systems have been transplanted quite thoroughly. Japanese advisors and trainers seem to have been quite important in the transfer of these systems. How well they function appears to vary across different companies and more time will be needed to judge their overall success. In most companies, the system appears to operates satisfactorily for routinized production process. However, whether the system can or will operate in a way that develops a self-generating innovative capacity remains to be seen.

Third, human resource management and industrial relations. This is the area where some unique developments and considerable variations in policies are observed in the different companies. These developments appear to be inevitable, reflecting the efforts of companies to respond and adapt to local social, cultural and political conditions in which

they find themselves. For instance, their strenuous effort in selection and training reflects their inevitable response to local conditions. The simple single rate wage scheme which accompanies the broad and single job class reflects an inevitable adaptation of the Japanese compensation system to U.S. norms.

The most striking adaptation is their response to trade unions. As reviewed earlier, some Japanese companies are working with the UAW while others are staying away from them. In Japan, trade unions are important supporters of the production system and function as an indispensable partner of management. Why do their responses to unionization differ? Formally speaking, the status of unions at any particular plant represents the preferences of those who work in it. However, such basic actions as the choice of plant location do reveal different attitudes among the managers of the various investment projects.

In our judgment, the cause of this variation is not their innate attitude towards unionization per se as much as their perceptions of the local conditions and specific characteristics of union leadership. In other words, they seem to be willing to work with unions, as they all have been doing for decades in their home country, if they can share basic goals and policies with the union in carrying out production activities. It appears that a large and important opportunity exists for both Japanese investors and American unions for mutual learning and collaboration in the future.

In interpreting the technology transfer experiences as summarized above, let us tentatively evaluate the performance of the transfer to date, and its long-term viability. One is on the performance of transfer. It appears that the transfer has been successful, overall. The transplanted systems have been working well at least in the routinized aspect of production. Whether the self-generating innovative capacity of the Japanese model of humanware, the most viable and critical property of the system, will develop is yet to be seen. These North American plants have been in operation for a relatively short period of time. This innovative quality may emerge in a matter of time, or other changes may be needed to foster it.

As for the long-term survival of the Japanese model of humanware, the evidence suggests that it is viable across different social, cultural and political contexts. This is suggested by the performance to date in North America. The system has been working well in spite of considerable and wide-ranging compromises, adaptations, and adjustments to varying local conditions. This viability may be demonstrated most clearly by the fact that workers on the shop floor appear to understand the underlying logic of the system and to participate effectively in its operation. If the system is having any problems adapting to the social context of North America, they may be more with managers and engineers than with workers at the workshop. We will return to this question later.

B. Long-Term Issues and Prospects

Japanese plants in the U.S. have so far been working quite successfully. Their successful operation, however, may well have been supported by helpful short-run factors.

One is what may be termed the "start-up" effect. Workers are attracted by the newness of their experience and by participating in new experiments. Workers appear to be particularly impressed by the full-fledged recognition given to them by the Japanese management, which is an important element of their new experience. Second is what may be called an "employment" effect. Some workers are satisfied simply by being able to secure the opportunity of employment. Japanese investment projects have provided decent employment opportunities to many workers who had been either laid-off for extended periods of time or searching for better jobs in vain. The third factor is related to the relatively small size of these plants. Those companies in particular which started out with a very small workforce have been able to take advantage of close face-to-face communications between management and employees and among employees themselves, providing additional motivation.

In the long run, however, these conditions will not last. Start-up effects are likely to diminish and eventually disappear. Employees who grow accustomed to employment security will no longer be motivated by the availability of employment opportunities. With the growth of these operations, their organizational complexity will grow, and close face-to-face communications will be reduced substantially.

When these helpful factors from the initiation period phase out, how will the Japanese investments supplement or reinforce their efforts so that the system will continue to operate successfully, particularly in the area of humanware? The critical questions and challenges would seem to lie in the area of human resource management, particularly maintaining and increasing employee motivation. How can they devise motivators which will work effectively in the long run?

Above all, one critical area of interest is reward systems. As we have pointed out earlier, Japanese companies are currently using a relatively simple wage scheme for non-exempt hourly workers. To the extent that Japanese management holds strongly to a single and broad job class system, adoption of a single wage rate scheme appears inevitable, given the norms of the American labor market. This wage system, however, gives rise to important questions as to how to promote and control the motivation of workers without reflecting their individual performance in their compensation.

Even if the norms in the American labor market will not tolerate differentiation in compensation among individual workers on the basis of work performance, as Japanese managers appear to believe, the reward system is only a small part of the comprehensive system of American industrial relations discussed in Section II. The reward system developed in Japan, which is presumably congruent with the Japanese production system, is quite different from the system currently employed by the Japanese companies in the U.S. Will the current system of single wage rates will be reformed in the future? Or will the Japanese reward

system which emphasizes individual differentiation and promotion will not turn out to be an essential element of the Japanese production system? In either case, the challenge for Japanese companies in the U.S. is to develop a reward system which effectively utilizes the potential of human resources within the framework of the Japanese production system and yet is acceptable from the viewpoint of American norms and expectations.

C. Lessons for American Industry

During the period when Japanese auto makers built their cars in Japan and exported them to the United States, the American auto industry was able to dismiss their success as deriving from culturally-derived social cohesion and such concrete advantages as lower compensation rates and favorable exchange rates. The idea that the American industry could learn from the Japanese experience was ridiculed, even when Japanese productivity, quality, and sales levels surpassed those of American companies. However, with the growing success of Japanese companies in the United States, using Japanese methods of production in large-scale operations and employing American workers and managers, the motivation for learning from their experiences has become strong. Their experiences can no longer be dismissed lightly.

In fact, during the last decade, specialists in the American auto industry did pay attention to Japanese auto makers and collected much information about them. Ample knowledge has been accumulated by specialists in the American auto industry about Japanese management

styles, production methods, corporate strategies, and human resource management policies. The issue, now, is what real lessons to draw from such a stock of knowledge. In other words, how can this knowledge be used to improve the American auto industry?

The interest of American industry in Japanese systems of management and production seems to be concentrated more in the area of social organization than anything else. In fact, a number of innovative attempts pursued in American plants, inspired partly by Japanese experience, emphasize team work, worker responsibility and participation, and labor-management cooperation.

Japanese managers emphasize these practices and values as well. However, it is important to recall that they do so not for altruistic reasons but because the survival of their production system depends upon the effectiveness of human resources. It is for this technological reason that Japanese management spends enormous resources in its effort to educate and train human resources. It is for this same reason that Japanese management commits itself strongly to the workers rather than the other way around. This interdependence between production technology and human resources naturally has profound implications for industrial relations policies as well.

The challenge for the American auto makers, if they wish to learn real lessons from the Japanese experience, is how to make all tiers of managers and engineers in their corporate structure understand and accommodate this technological message in their day-to-day operations.

The challenge is probably harder than it seems. This is because the acceptance of such a model of humanware would seriously affect the "power base" of middle management and engineers, and possibly of local union officials.

The changes suggested by the Japanese model are often welcomed by both top management and workers on the shop floor. Top management is willing to advocate and suggest such changes because they may bring about improvements in productivity and other aspects of corporate performance. Workers are willing to accept such changes because they can enjoy a greater degree of recognition from the management, increased discretion and control on the shop floor, particularly over work processes, and presumably more secure employment opportunities. Such a change might be instrumental also for international union leaders who recognize the current difficulty of the industry and are attempting to improve the situation from the industrial relations side.

In contrast, these changes might well erode the traditional power base of middle management in corporate organizations since their power is based on the possession and control of critical information. The Japanese model of humanware presumes that all relevant information for production and other corporate activities is openly shared by and with all employees. Intensive and extensive information sharing is essential if the merits of Japanese-style teamwork are to be realized. Pursuit of the Japanese model of humanware, therefore, may interfere and conflict with the basis of authority and power of middle management. The power

base of engineers may be threatened likewise, and possibly more seriously, for similar reasons.

Also the adoption of the Japanese model of humanware may mitigate the political strength of local union leaders operating in the conventional political structure of industrial relations. The Japanese model emphasizes informal communication and labor-management cooperation. Adaptation to this model may weaken the political appeal of local union leaders in the eyes of members who are accustomed to a confrontational mode of industrial relations. The political position of local union leaders, who have vested interests in the conventional structure of industrial relations, may therefore be threatened by the introduction of the Japanese model.

For these reasons, we suspect that the changes implied by the Japanese model of humanware will have a substantial impact on the power base of key groups in the industry -- middle managers, engineers, and local union leaders. Their resistance to change may be stubborn and strenuous. This is because internal rewards, incentives, power and authority are all mutually interdependent in the conventional system of production and industrial relations. A system that has worked so well historically, as discussed in Section III, will not be easy to change swiftly without thorough restructuring and reform of all its components. Whether the U.S. auto industry can learn readily applicable lessons from the Japanese experience will depend on how much the conventional American systems of production and industrial relations can accommodate

change through modification of their internal power structure and reward system.

D. What Can Japan Learn?

Japanese companies can learn a great deal by investing and operating in the United States. Current operations in the United States provide Japanese companies precious opportunities to collect information and accumulate know-how through the actual production experience. Such know-how and experience can be useful and will be utilized when their operations are expanded and more diversified in the future. In other words, their current experiences will serve as a stepping stone for their future development.

More fundamentally, however, there seem to be several basic questions which Japanese corporations must face in the long-run. One is the question of how they will fare competitively with American auto makers over time. Given the anticipated large productive capacity of Japanese companies in North America in addition to their direct exports to the U.S., will all of them be able to survive in the long run? If they do survive, will American competitors be forced to contract their production capacity? This will affect seriously not only the future course of Japanese and American automobile companies, but also employment opportunities for U.S. workers, business opportunities for suppliers from both countries, and, more broadly, international relations between the U.S. and Japan.

Second, how will Japanese companies develop a model or models which will work in the long run in the social, political, and cultural context of American society? The successful development of the Japanese auto industry in Japan has been supported by a well-integrated complex of hardware and production management technology, human resource management, industrial relations, and inter-firm organizational arrangements. How successfully can Japanese investors transplant critical elements of such a highly integrated production system and still acquire the necessary understanding and participation of American workers, managers, suppliers and dealers?

For example, there appears to exist striking differences between Japan and the U.S. in the area of OEM (Original Equipment Manufacturer) relationships with suppliers. While the American relationship may be summarized as primarily a bargaining relationship, the Japanese have a more long-term relationship with their suppliers in which mutual development is sought through the sharing of information and resources. American suppliers who are used to bargaining situations and tend to behave accordingly, therefore appearing untrustworthy to Japanese eyes, while the Japanese approach appears to American suppliers seeking entry as conspiratorial and unfair. This reflects only one of many difficult tasks facing both Japanese and American companies in order to cultivate mutual understanding and to make the adjustments necessary for productive and stable relations in the future.

Third, how will Japanese companies deal with American unions in the long-run? As discussed earlier, labor unions have played an

integral role in Japan of supporting the production system as a partner of management. The Japanese system of production, which is so heavily and sensitively dependent upon the active and effective participation of employees, could not have developed as it did without the support and cooperation given by the unions. It is also hard to conceive that Japanese auto companies in the United States will be able to stay away from American unions in the long-run. Although specific arrangements may differ among different companies, some sort of productive relationship will have to be developed between unions and companies in the long-run.

These represent only some of the essential questions that Japanese investors will have to face and solve if they really wish to obtain social acceptance in American society. The matter of importance for Japanese investors is to obtain general and public acceptance, particularly as their presence grows increasingly large. With the growth of their presence and visibility, the need to acquire public understanding and acceptance will grow significantly. They will constitute an important segment of American business, as well as being significant social institutions. While their products are the most tangible means of obtaining the acceptance of Americans as consumers, Japanese corporations as social and public institutions will also have to cultivate public understanding effectively in order to be accepted by American society in the long run.

VI. CONCLUDING REMARKS

What we have presented in this paper are preliminary and tentative findings drawn from our modest research on the variety of experiences of the Japanese automobile companies that have invested in production facilities in the United States.

Since the experience of these companies has been relatively brief in duration, and some investment activities are just now unfolding, our findings and suggested implications are by no means conclusive. Another limitation of our study is the small sample under observation. There are only six plants, including joint ventures and those wholly owned by the Japanese, available for study, and only three of them are actually producing cars at this time. This makes it difficult for us to carry out any rigorous quantitative comparative analysis.

Notwithstanding these limitations, the experiences to date of these plants certainly suggest some intriguing patterns and trends. Even though the number of companies involved is only a handful, their expected impact on the American automobile market and industry will be enormous, as evidenced particularly by their anticipated volume of production of two million cars by 1988. There is no doubt that their experience operating in the U.S. can provide the American industry with extremely important opportunities to learn different approaches to the manufacturing process, human resource management, and industrial relations.

In lieu of a conclusion, let us point to three general implications which can be extrapolated from our research findings.

First, the experiences of Japanese automobile companies investing in the United States suggest that technology transfer, in our broad sense of the term centering around the concept of humanware, has been carried out successfully. The logic of the Japanese production system and the critical role of human resources in its functioning appear to have been understood and accepted by American workers. The Japanese model of humanware has worked quite well so far, in this respect. At least for the short term, the transfer of this approach seems to be successful.

Second, there are lessons for the American industry from this experience. Whether the American industry could learn a real lesson from the Japanese experience in the sense of using it to improve their own performance seems to depend critically on how effectively they can change their internal structures, particularly organizational and social structures. To put it more specifically, the question is how managers, engineers, production workers, and union leaders can share information and work together across social and organizational boundaries. The mere introduction of fragments of Japanese management techniques without fundamental changes in the social structure within organizational settings will not recoup the merits of the Japanese model of humanware. This is a harder challenge than it may appear, particularly because the conventional American production system has been so compatible with American social structure that those who have lived with it for years

may have little inclination to change it or dispose of it, despite the defects which are theoretically visible.

Third, there are lessons for Japan from this experience. The Japanese model of humanware has basically proved its short-run applicability and viability as a technological system in spite of the social, cultural, and political differences confronting its transfer. Ironically, this suggests that the real test for this model will come in modifying it to work in different social, cultural, and political environments over the long run. So far, Japanese investors have made the utmost effort to transfer their humanware technology, particularly on the shop floor. As their operations grow larger and their presence becomes more permanent, they will soon face the same issues that the American auto industry will face if it tries to introduce the Japanese humanware model. In other words, the Japanese investors will also have to work with and solve ongoing issues arising from the social, cultural, and political constraints and characteristics of American industrial society. Unless their technological message is understood and accepted not only by shop-floor workers but also by the bulk of American managers, engineers, suppliers, and the public, the future prospects of Japanese companies, as they become a larger presence, being accepted by American society are not good. The Japanese will need to embark soon on a major effort to obtain public understanding and acceptance in these broader social, cultural, and political domains as the next vital step in increasing their investments and influence in the United States.

NOTES

1. Japanese investment is growing also in Canada. Since Canada maintains a free trade relationship with the U.S. for automobiles, this investment will also add significantly to the Japanese presence in the North American auto market. As of the summer of 1986, Honda of Canada Manufacturing (HCM) was preparing to begin production in Alliston, Ontario. Toyota has started a construction project in Cambridge, Ontario, through its Toyota Motor Ontario affiliate (TMO). A GM-Suzuki joint venture has made preliminary arrangements to build a Canadian plant, including discussions with the Canadian Auto Workers union.

2. In October 1984, Consumer Reports wrote that they had tested a Honda Accord made in Ohio and that "it was finished at least as well as any model made in Japan." In April 1986, Consumer Reports said that the Chevrolet Nova they tested, which was built at NUMMI (the GM-Toyota joint venture), was a "well-built, high quality car, essentially a Toyota Corolla [which is manufactured in Japan] with Chevrolet nameplates." Similarly, NUMMI was, as of the summer of 1986, producing the highest quality cars at General Motors, according to GM's weekly internal quality audits, regularly scoring from 136 to 139 on a 145 point scale. [authors' interview notes]

3. NUMMI's labor productivity has been estimated as 50% higher than the General Motors Fremont plant formerly occupying the same site, using essentially the same technology and a workforce drawn completely from a pool of laid-off Fremont workers. Cf. Note #33 and Krafcik, John "Learning from NUMMI", Internal Working Paper, International Motor Vehicle Program, M.I.T., 1986.

4. For example, absenteeism at NUMMI is reported to average 3-4%, compared with levels as high as 25% in the previous GM-Fremont plant, and the number of formal grievances filed is negligable. [authors' interview notes]

5. Estimates of the planned production by Japanese auto makers in North America hover around a total volume of 1.5 million cars. According to one auto expert, the total volume would be 1.46 million cars, of which 1.33 million would be built in the U.S. and 130,000 in Canada, excluding Suzuki. (Yoshida, Nobuyoshi, Soshite Honda wa Tonda (And Honda Took Off), Tokyo:Jitsugyo no Nihon sha, 1986.) An internal GM estimate suggests a total production of 1.66 million (1.47 million in the U.S. and 0.21 million in Canada.) Nissan Research Office disclosed a prediction recently that in two years the supply capacity of small cars in the U.S. will exceed the demand by a large margin, which would seriously threaten the survival of some manufacturers. Their estimate is 1.59 million (1.41 million in the U.S. and 0.18 million in Canada), Mainichi News Paper, June 25, 1986.

6. This view of technology differs from that often used by economists, both because of the expansion of the concept to include the interlocking role of human resources with hardware, and because it is a dynamic view, concerned with technology in use and how to explain variations in its performance. The traditional, more static view of economists assumes technology to be the embodiment of the most efficient means of production available at a given level of scientific knowledge, units of which can be purchased through the investment of capital. The interaction between this technology and human resources is described in terms of what skills a given technology requires which the firm must obtain. This investment in necessary human skills, or human capital, follows directly from the technology most applicable to a given production setting.

This deterministic view is challenged by some social historians, who claim that the choice of technology derives more from assumptions about the capabilities of the people who use it and managerial goals of controlling the workforce than any technical logic of efficiency. This is an equally static view, however, which again misses the interaction of hardware and human resources over time, and the degree to which a learning cycle can develop, leading to modifications in both hardware design and configuration and human skills. Perhaps the closest view of technology to ours is that contained in the socio-technical theory developed by Eric Trist and his colleagues.

7. Abegglen and Stalk emphasize "growth" as an important goal of Japanese corporations. Abegglen, James C. and Stalk, George Jr. Kaisha: The Japanese Corporation. New York: Basic Books Inc. 1985.

8. Such an inventory incurs not only the labor cost of the workforce directly involved in handling the materials and intermediate parts, but also the indirect costs of related administrative jobs as well.

9. To illustrate this important point heuristically, an anecdotal explanation is often given using the example of sailing on a lake. When you sail on the lake, if the level of water is high enough, you do not worry about the shape of the bottom. Likewise, if the level of inventory is high in the case of production, you do not worry about problems or defects in the production process because you can always resort to buffer stocks. In contrast, when the level of water is low in the lake, sailors have to be careful about the rocks and reefs at the bottom. Similarly, if the level of inventory is low, workers and engineers need to be careful of problems in the production system. If they do not solve the problem, their production activity would likely be disturbed seriously. The Japanese system is designed to expose problems rather than conceal them, and workers and engineers are encouraged to find and solve problems as early as possible to improve the system even at the possible cost of short-run disturbances.

10. A typical example of the "pull" system is Toyota's well-known method of Kanban. Nissan employs a similar method, known as the Active Plate Method (APM). Honda does not use any such identifiable method. However, it does exploit the flexible and cost-saving merits of the "pull" system wherever applicable. An excellent and detailed exposition of the Kanban system is given in Monden, Yasuhiro, Toyota Production System: A Practical Approach to Production Management. Atlanta, GA: Industrial Engineering and Management Press, 1983, especially chapters 2 and 3.

11. A good example of such feedback may be found in the close coordination between the stamping section and the welding section within the same plant. When press machines are operating side by side with welding and assembly sections, defective parts found in the welding section can quickly be fed back to the stamping section. And if stamping is done in small lots, any problems can be solved before a large number of defective parts are stamped. A well-coordinated production system using a small lot production approach can thus minimize product defects and also the costs associated with final repair. Japanese plants locate their stamping section very close to the welding and assembly sections for this reason.

12. In Toyota, this effort is described by the general term "kaizen".

13. Toyota's "jidoka" concept is a typical case in point. Monden translates this "jidoka" concept into English as "autonomation" (Monden, ibid, pp. 140-150.) which implies autonomous defect control. This concept of autonomation is meant to convey the combination of mechanical automation and human control. Mechanical automation on its own can be problematic, because if something goes wrong in the production process, it can produce defective parts automatically. To prevent the losses which can sometimes arise from automated production, it is necessary to make machines stop whenever defects or problems are identified.

"Autonomation" implies the attachment of extra functions to automated machines so that the machine will stop automatically when some deviation in product quality is detected or when the required quantity has been produced. Thanks to the continuous improvement efforts related to "jidoka", many machines in Toyota factories are now equipped with mechanical check devices and foolproof systems to aid human judgment.

Mazda has promoted a major campaign since the late 1970s to develop and implement automatic foolproof devices in their production systems. These devices are often called "poka yoke" or "avoiding mistakes". Through innovative activities at the workshop, a number of improvements have been made and as a result unexpected machine stoppages have been reduced appreciably and consequently the capacity utilization ratio of production facilities has increase markedly. For details of Mazda's experience, see Nihon Noritsu Kyokai, Mazda no Genba Kakushin (Mazda's Innovations at the Workshop), Tokyo:Nihon Noritsu Kokai, 1984.

14. Toyota has made major efforts, through the collaboration of production workers and engineers, to reduce the set-up time for machines. A symbolic goal of such efforts is to attain single-digit set-up, or machine set-up in less than 10 minutes. Toyota achieved a 3 minute setup for an 800 ton punch press in 1970 after many years of persistent effort. Monden provides a systematic and useful exposition of the concept and application of quick machine set-up (Monden, ibid, Chapter 6.

According to Monden, there are four major distinguishable concepts:

1. Separating the internal set-up (those things which can only be done once the machine has stopped) from the external set-up (those things which can be done before the changeover);

2. Converting as much as possible of the internal set-up to the external set-up;

3. Eliminating the adjustment process once set-up is complete;

4. Abolishing the set-up step itself.

The techniques applied to putting these concepts into practice include:

1. Standardizing external set-up actions;

2. Standardize only necessary portions of the machine;

3. Use a quick fastener;

4. Use a supplementary tool;

5. Use parallel operations;

6. Use a mechanical set-up system.

Mazda also sought to achieve single-digit set-up, beginning in the late 1970s, and then to one-touch instantaneous set-up. On the shop floor, they emphasized the importance of the ideas and suggestions of workers and engineers by targeting their focus on problem areas, carrying out practice runs of set-up operations and videotaping them. Noritsu Kyokai (1984), ibid, pp. 51-60.

15. Toyota's concept of "standardized work" is the essential building block for self-management of the work process. Establishing the appropriate work standards is regarded as the essential prerequisite for any successful innovation. Standard operations are determined by workers, according to the following steps (Monden, ibid, p. 86):

1. Determine the cycle time.

2. Determine the completion time per unit.

3. Determine the standard operation routine.

4. Determine the standard quantity of work-in-process

5. Prepare the standard operations sheet.

While the specific form may differ across different companies, the essential policy of workers establishing standard operations is followed by all Japanese auto manufacturers.

16. Toyota calls this effort "shojinka", which literally means to reduce workers. The idea to reduce the number of workers needed to perform a certain task by reorganizing and improving the content and process of the work, thereby increasing labor productivity.

17. Perhaps a more fundamental requirement for carrying out the reduction of labor inputs is the comprehensive preparation of basic conditions for production, including not only physical equipment but also the discipline and attitude of production workers. Mazda has carried out a special campaign to achieve this goal, called "total productive maintenance", which sets six specific targets, all of which start with 'S' in Japanese. They are: Seiri - sorting out necessary from unnecessary items; Seiton: organizing things so necessary items can be pulled out quickly when needed; Seiso - maintaining the cleanliness of machines and tools; Seiketsu - maintaining a clean and comfortable workshop; Shitsuke - observing the rules with rigorous discipline; and Sensu - sensitive alertness. Nihon Noritsu Kyokai ibid, 1984.

18. According to a Ministry of Labor survey of labor-management communications conducted in 1977, more than 70 percent of 5000 private enterprises with over 100 employees reported having an ongoing joint consultation system. Various surveys reveal that the system is more prevalent and clearly-defined the larger the firm size. Another tendency is that the percentage of firms having the system is greater for unionized firms than non-unionized ones. For further details, see Shimada, Haruo, "Perceptions and the Reality of Japanese Industrial Relations: Its Role in Japan's Postwar Industrial Success." Keio Economic Studies, vol. 14, No. 2, 1982.

19. Another aspect of the system's "fragility" emerges at the national, rather than corporate level. Enormous efforts are made to achieve the cooperation and participation necessary to make this production system work effectively, through careful management of human resources and industrial relations. But when this model overly dominates a nation's

industrial relations system, there is a risk for society as a whole that resource allocation will be distorted from an adequate social balance.

At the present time, Japan's economy is internationally imbalanced, because of its prolonged emphasis on export-oriented industries and its massive trade imbalances with the United States and other countries. Although some efforts to restructure the economy are underway, it will be difficult for Japan to increase domestic consumption enough to restore a healthier macroeconomic balance, in part because of the pattern of cooperative labor relations. In the current adverse economic conditions brought about by exchange rate realignments, the corporate logic of higher productivity and lower costs through worker participation and wage moderation by the unions contradicts the macroeconomic logic for the overall society, which calls for higher wages to stimulate domestic consumption. This argument is developed in greater detail in Shimada, Haruo, "Japanese Industrial Relations in Transition?", Working Paper, Sloan School of Management, M.I.T., December 1986.

20. The contrast is most clear with Nissan, which chose to follow the American production system model for many years. Although during the 1950s and 60s, Nissan did reduce lot sizes, die change times, and inventory levels below those of American companies, it was only in the 1970s that Nissan began to emulate Toyota's production methods. It is still the case that Nissan uses a "push" rather than a "pull" system of managing production flows and inventory levels and relies more heavily on advanced automation and computerized production control than Toyota. Michael Cusumano provides an in-depth and detailed description of the different patterns of production management and technology acquisition at Toyota and Nissan in The Japanese Automobile Industry: Technology and Management at Nissan and Toyota, Cambridge, MA: Harvard University Press, 1985, especially chapter 5, pp. 307-319.

21. Koike, Kazuo "Internal Labor Markets: Workers in Large Firms" in Shirai, T. (ed.) Contemporary Industrial Relations in Japan, Madison, WI: University of Wisconsin Press, 1983, pp. 29-61.

22. In fact, Toyota deliberately chose not to use American technology, which by the 1950s was becoming highly specialized, focusing instead on modifying general purpose machines in order to retain more flexibility in the production process. In constrast, Nissan's strategy was always to get the most advanced technology from wherever in the world it was available. But even when Toyota's and Nissan's strategy diverged most, they more closely resembled each other (in areas such as inventory levels and lot sizes) than any American company. And as the success of Toyota's innovative production techniques became evident, in the early 1970s, this divergence narrowed as Nissan and other companies scrambled to implement much of the Toyota system. See Cusumano, ibid, chapter 5.

23. Cusumano provides a well-informed description of the development of "total quality control" through the initiative of Dr. Ishikawa. See

Cusumano, ibid, Chapter 6. Also see Ishikawa, Kaoru and Lu, David J. What is Total Quality Control: The Japanese Way, New Jersey: Prentice-Hall, 1985.

24. On the significance of the postwar transformation of the Japanese labor movement and industrial relations, see Shimada, Haruo, "Japan's Postwar Industrial Growth and Labor-Management Relations", Proceedings of the 35th Annual Meeting, American Industrial Relations Association, 1983, pp. 241-247. Also see Shimada, Haruo, "The Perceptions and Reality of Japanese Industrial Relations," in Thurow, Lester C. (ed.) The Management Challenge: Japanese Views, Cambridge, MA: MIT Press, 1985.

25. An excellent historical analysis of the development of the American system of manufacturing can be found in Abernathy, William, Clark, Kim, and Kantrow, Alan Industrial Renaissance, New York: Basic Books, 1983. A broader discussion of the rise of the mass production model can be found in Piore, Michael and Sabel, Charles The Second Industrial Divide, New York: Basic Books, 1985, and Chandler, Albert, The Visible Hand, Cambridge, MA: Harvard University Press, 1977.

26. This "relative prices" argument has considerable intuitive appeal in contrasting the U.S. and Japanese experience. It is somewhat misleading with regard to land. While Japan undeniably has less open space than the U.S., there was no shortage of space to build automobile plants in Japan in the 1950s and 1960s and land prices were quite low. It is the case, however, that interest rates were much higher in Japan than the U.S. during the 1950s and 1960s, when the Japanese industry began to grow. In the 1970s, however, when the Japanese industry was experiencing its greatest expansion, this situation was reversed, with interest rates much lower in Japan.

27. Altschuler et al. describe the three historical transformations of the automobile industry, the first of which was dominated by the American industry and the success of its mass production techniques, the second of which was dominated by the Europeans and their product differentiation strategy, and the third of which has been dominated by Japanese innovations in the production system. Altschuler, A., Anderson, M., Jones, D., Roos, D., Womack, J. The Future of the Automobile: The Report of M.I.T.'s International Automobile Program, Cambridge, MA: MIT Press, 1985.

28. A production manager at the Marysville plant commented that Honda has much room for improving the efficiency of its material handling:

> Our material services group does not want to break down to a Just-in-Time system. They do not want to handle additional breakdowns. We built a racking system to hold inventory. I used to get seat belts in sets of 60, because we run lots of 60. Then it changed

> to lots of 240. Four times the floor space. But material services wouldn't break them into 60s because they receive them in 240s from a domestic vendor and in 60s from the Japanese vendor.
>
> I have slower quality feedback, higher cost for inventory, and more handling because I have a rack for my domestic parts. I bring a skid in, store it, take a skid out. It's a bit of the U.S. approach to material handling seeping in.

Source - authors' interview notes, May 1986.

29. According to Cusumano's calculations, the inventory turnover ratio for Honda was 13 for the period 1980-1983, much lower than Toyota's level of about 30, and close to the level of American manufacturers. Cusumano, ibid, pp. 301-303.

30. Honda's Canadian plant in Alliston, Ontario does not have this feature in its plant design. This plant will receives its supply of stampings from Honda's U.S. plant. This unique attempt suggests that Honda may have overcome many of the traditional technological and quality problems arising from the separation of stamping and assembly operations.

31. Yoshida describes this as the approach of culturing "Yeast". Yoshida, N.. ibid, 1986.

32. Honda Engineering Company played an important role here, especially during the start-up phase of production and whenever major model changes or the introduction of new production equipment occur. Furthermore, Honda Engineering designed and constructed a second assembly line, now used to produce the Civic, nestled close by the Accord assembly line and utilizing very little additional floor space. The construction of this second line was carried out without shutting down the plant, and it was started up within the period of one week in the summer of 1986.

33. Perhaps the most notable achievement has been in labor productivity. NUMMI's scheduled capacity is 250,000 cars with slightly more than 2,000 workers, while the old Fremont plant produced 325,000 workers with about 6,000 workers. This gross comparison suggests that NUMMI's labor productivity is more than twice that of the old GM Fremont plant, an estimate which surely overestimates the actual productivity differential. Krafcik adjusted these estimates to take into account such relevant factors as the number of welds needed, the types of cars made, the option content, relief time, and so forth, and found a productivity differential which placed NUMMI about 50% above the old GM-Fremont plant. Krafcik, John, "Learning from NUMMI," Internal Working Paper, International Motor Vehicle Program, MIT, 1986.

34. In chapter XXVIII of the Collective Agreement between NUMMI and the UAW (Local 2244), it is stated that "employees are encouraged and expected to participate with the Team Leaders and Group Leaders in design and establishing Standardized Work.... This includes items such as required manpower, takt time, model mix, operation arrangements, tools, operation methods, and required time for performing operations." NUMMI-UAW Agreement, p. 57. A detailed explanation of the necessary steps for establishing and modifying "standardized work" is found in Appendix C of the Collective Agreement.

Two quotes from NUMMI employees, the first from a union member and team leader, and the second from a former union official who is currently a group leader, reveal their positive reaction to standardized work:

> "Here we do standardized work. When I first started, I didn't understand what difference it made if I did it one way this time, and another way another time. But they explained to me and trained me that you get better quality if you do things the same way every time. You're less likely to make mistakes, and the quality will be better."
>
> "We were told that the hourly worker for the first time in American history was going to set their own work standard. I was very excited that for the first time, some engineer is not going to tell me how to do my job. Me and my four workers are going to sit here and decide how we're going to build a door. .... For the first time, the hourly worker was really going to understand his job."

Source - authors' interview notes, June 1986.

35. Of the 3.2 million square feet in the overall plant complex, the stamping area and body shop occupy 1.23 million square feet, the paint plant takes up 0.51 million square feet, and the assembly plant takes another 1.23 million square feet.

36. Albert Kahn Associates, located in Detroit, Michigan, designed the facility and Daniel Construction Co. of Greenville, South Carolina acted a general contractor.

37. The paint section is one of the most impressive examples of combining sophisticated equipment from American and European manufacturers.

38. New Nissan Motor Corporation (NNMC) utilized, as of the summer of 1986, more than 90 domestic parts suppliers.

39. By the end of 1985, the Japanese staff was reduced to only 15, who functioned mainly as advisors.

40. The notion that workers cannot walk in and take a job at NNMC without appropriate vocational preparation and training appears to be widely prevalent and accepted among those who are interested in working for the company. Source: authors' interviews with workers both inside and outside the plant.

41. The features described here are more or less shared by the Honda, Nissan, and Mazda plants in the U.S. Source: the authors' interviews with personnel managers at these companies, workers, and job applicants.

42. Two quotes are indicative of this focus on problem-solving and teamwork. The first is from an applicant for a production job, and the second is from the personnel manager of one of the companies.

> "We had a group interview, nine of us at a time. They asked about the production line. They asked what would happen if you were working on the line and someone before you forgot to put a bolt in and you put the seat on over the bolt - what would you do if the seat went on with no bolt and lots of them went off to shipping. There were lots of questions like that.... Really deep thinking. They start out with that and then make it more complicated."
>
> "We're looking for well-developed teamwork skills - people who enjoy the interaction of working together in problem-solving groups or teams... Their experience is not as critical for us as their attitudes and behaviors. A person could have worked in an environment where he or she was the best painter, but did not exhibit the skills and attitudes needed to work in a team, to problem-solve together, to continuously look for improvement. If we don't see those, they probably are not going to get a job offer."

43. For example, one typical three-week training program for NUMMI supervisors conducted at Toyota facilities in Japan in the summer of 1984 included the following sessions. The first week was spent on orientation -- three days devoted to introducing the basic ideas of the Toyota production system through lectures and plant tours, and two days of on-the-job orientation in an appropriate production setting. The second week was spent entirely in on-the-job training, in which the trainees worked together with an assigned trainer in an actual production position. The third week continued this on-the-job training, and added some on-the-job exposure to supervisory practices. The final day was spent meeting and talking with officials from the Toyota union and labor relations managers.

44. Here are some quotes on training, the first from the assistant manager of stamping at Honda (a former production worker), and the second from a team leader at NUMMI:

> "I think everyone learns something new everyday. We don't have specific training sessions. You learn by working together. You can't just sit down in a room like this and say, "This is stamping, this is how you do it. It's more on the job, actually working side by side. We learn a tremendous amount from the staff engineers in stamping (experienced Japanese production workers who function as full-time trainers). It seems like the farther along we're getting, we're learning more from each other than we were 3 or 5 years ago."

> "I used to work for General Motors. They trained for maybe half a day and then said 'That's your job'. Under the Japanese, they were constantly helping me, watching me, and checking my quality. That was new to me. It was very good for me, because it helped me think they really cared about my work."

45. This quote comes from a Honda department manager, who was sent to Japan from his job for five weeks of training on motorcycle engines while still a production worker:

> "I returned and shortly after that, with all my engine experience, I was promoted to production coordinator, but in a different area of assembly. Which I found very strange. I couldn't understand why I was being promoted but moved to another area. The company had already spent five weeks of time and energy and money to teach me everything that could be known about these engines. I asked a question at the time, and the answer I got was 'We recognize that you have some ability, and we don't want you to only learn about engines. The more you know, the more versatile you are.' I'm living proof of that, because I've been in several areas now.

46. This quote is from a production worker at Nissan.

> "With the company moving as slow as it is, I don't worry about advancing as fast. But I do have the kind of job where I feel around, do a bit of management work. I do repair work so I have to work with people real close. They know that one of these days I want to be promoted. Right now, there aren't any, so I try not to get discouraged. If there was a lot of movement and I felt I didn't get considered, I might feel down about it. But now, nobody's moving, so who am I going to be mad at? You try not to think too far ahead."

47. NUMMI-UAW agreement, Section XVII, pp. 30-31.

48. NUMMI-UAW agreement, Section XXIX, p. 59.

49. In fact, in order in insure that autonomous work teams are self-contained and able to control their boundaries vis-a-vis other groups, the production process is set up to allow a buffer of in-process inventory between each team. This clearly violates the premise of a Just-in-Time inventory system. This has led Prof. Janice Klein, from Harvard Business School, to speculate that a Just-in-Time system may be incompatible with the typical American implementation of work teams. Conversation with the authors.

50. This quote is from Honda's assistant manager of stamping:

"There's a very wide range of movement, from just between jobs on the team, or team leader to team leader, or coordinator to coordinator. It's connected to promotions also, you might say, because it's a different jobs and something new. But the basic on-the-floor plan is that we want everyone to know everything about the department. Right now in stamping we do not have one set rotation plan. Everyone works different. Everyone has their own personality, and lots of times one person may not do the jobs as well as another person. But we try to get everybody to at least know each job and work with it."

51. This quote is from a production worker at Nissan:

> "We rotate every day. From 7:00 to 10:00 I may put seats in. From 10:00 to 12:00 I may work in the pit. From 12:00, something else. I may do four jobs in one day. It depends on how versatile you are. If you are quite versatile, you may do as many as 8-10 jobs in a week. Then again, you may do the same four jobs over and over. You're never on one job for more than three hours at a time."

It should be noted that there is considerable variation in rotation policy across departments at Nissan. We were told that other departments rotate much less often, every four or five weeks. But in each department, the rotation plan is clearly specified.

52. At NUMMI, transfers to open jobs are made through an application process. Selection is based first on management assessment of whether the employee "has the capability and knowledge to perform the job." Where two or more employees are judged to have relatively equal capability, "the employee with the greatest seniority will be transferred." This is the primary use of seniority, which is based on time working at NUMMI and not previous GM seniority. NUMMI-UAW agreement, Section XII, p. 54-55.

53. This quote is from a production coordinator (former production worker) in the finishing area at Honda.

"A person in this area needs to have lots of different skills. People who work in finishing often come from other areas, maybe from where they make the doors so they understand the problems that can come from over there. My background is in welding... (laughs) They had to drag me over here. It was, let's say, a mutual agreement. For my education. Before, [in welding], my concentration was safety first, because there's so much machinery and people working in close quarters, and second, how the machinery was running, because that affects quality. Sometimes you'd think, 'oh well, there's someone down the line who can fix this for me.'...But now I'm at this end, and we have to fix all the problems when they get here."

"We don't have any bidding process, and we don't have a set sequences. You don't have a rigid rule that when you're hired in, you go here, here, and here. Some people show a special skill for finishing, so you try to steer them in that direction. Some people show a special skill for mechanics or electrical or hydraulics, so you'll encourage them towards that equipment. Each person has some special skill inside, so you try to find what that is and encourage a person."

54. The beginning wage for an associate in the production group was $10.00 per hour, in the spring of 1986, with a planned raise to $12.00 per hour after 18 months. (Yoshida, ibid, 1986. pp.142-3) Honda calls this a "highly competitive wage," (Honda of American Associates Handbook, p. 1) and it is apparently considerably higher than the majority of jobs in the local labor market.

55. For hourly production, material handling, and quality assurance technicians, the starting wage is $10.90 plus $1.35 bonus, $12.00 plus $1.35 bonus for the second year, and $12.25 plus $1.35 bonus for the third year. For a maintenance technician, the starting wage is $13.34 plus $1.35 bonus, $14.34 plus $1.35 bonus for the second year, and $14.64 plus $1.35 bonus for the third year. For the night shift, a $.50 premium per hour is added.

56. The NUMMI-UAW Agreement prescribes the following contracted wage rates, which were made effective on July 1, 1986.

For hourly employees of Division I (production), the hiring rate is $11.29, $11.95 after 6 months, $12.62 after 12 months, and $13.28 after 18 months from hiring. For Division II employees (tool and die makers), $15.05 for hiring, $15.55 after 90 days from hiring, and $15.95 after reaching the qualification of die tryout. For general maintenance employees, $14.90 for hiring, and $15.40 after 90 days from hiring.

57. This quote comes from a manager at Honda (former production worker):

> "I think everyone who works here has a tremendous amount of pride. It's the small things we do. You can give people money and money and money. But it's the small things the company doesn't have to do, that they go out of their way to do. Personal recognitions means a lot to people. In another company, you may not get what you deserve. For people to know that what they say and think has value means a lot to them.

58. NMMC states quite explicitly in its Employee Handbook that "We do not favor a union because we strongly feel that unionism would be detrimental to both the Company and to all employees. We prefer to deal with each other directly rather than through a third party." (Employee Handbook, p. 8)

59. When the UAW, after a long campaign at Honda, asked for recognition without an election, claiming sufficient support, the company undertook an internal survey and reported that nearly 80% were opposed to joining the union.

60. It is important to note that the hardware technology used by Japanese companies is not necessarily highly sophisticated. Both Honda and NUMMI began their operations with relatively unsophisticated equipment. Then, as the skill and adaptability of the workforce, and their mastery of the Japanese production system has grown, more advanced equipment has been brought in. It appears that new technology is more quickly and effectively implemented in these Japanese-managed plants than in traditional U.S. plants because of the emphasis on learning and incremental innovation.